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Emissions of NO(sub X) and SO(sub X)
Volume 2. Appendices

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TESTING OF WALL-FIRED FURNACES TO
REDUCE EMISSIONS OF NO_x AND SO_x

Volume 2

Appendices

by

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ABSTRACT

The report gives results of a study to clarify the processes that control sulfur capture by dry sorbents injected directly into a pulverized-coal-fired system, and to develop methods for generalizing data from one test furnace to another and from test facilities to fired application.

Most experiments were conducted in a 1 million Btu/hr down-fired furnace to determine the effects of: fuel type, sorbent type, injection location, peak flame temperature, SO_2 concentration, and burner zone stoichiometry.

Conclusions of the study included:

- (1) The concentration of SO_2 in the natural-gas-fired tests had a slight effect on sulfur capture, increasing capture at $\text{Ca/S} = 2$ from 26 percent at 500 ppm to 40 percent at 3500 ppm SO_2 ;
- (2) The concentration of mineral matter in the system had a very strong impact on capture at all of the SO_2 concentration levels and Ca/S ratios tested;
- (3) Injecting the sorbent downstream from the main flame resulted in improved utilization in coal flames; and
- (4) The effect of sorbent type on capture with a given fuel was dependent on the firing conditions--including sorbent injection location and thermal conditions (the hydrated limes seemed to be most sensitive to thermal conditions and the Vicron limestone least sensitive).

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APPENDIX A--FACILITIES

A.1 Boiler Simulator Furnace Design

The Boiler Simulator Furnace (BSF) was developed for studying sulfur pollutants from boilers as part of Task 2 of EPA Contract No. 68-02-2667. The BSF experimental furnace system was designed to produce variable combustion conditions in order to simulate a wide variety of coal combustor firing schemes including:

- Wall Firing
- Tangential Firing
- Turbo
- Arch
- Tower
- Steamer
- Cyclone

There was no attempt to simulate directly the hardware of each of these types of firing systems; the BSF design tried to include conditions typical of the various systems. In particular, the unit was designed to simulate the time/temperature/stoichiometry history of an actual full-scale, utility boiler. Detailed consideration of the flame zone, radiant zone, convective passages and the particle collection equipment were included in the design-criteria review. The furnace was designed to operate over a wider range of combustion conditions than are typical of current commercial practice.

The design criteria included the following:

- Independent control of wall temperature throughout the furnace and convective sections.
- Fuel consumption rate nominally 80 lbs/hr (1×10^6 Btu/hr coal).
- Variable burner design.

- Variable preheat of all combustion air streams.
- Simulation of large particle loss to furnace bottom.
- Ability to quickly and easily clean interior sections.
- Potential for near adiabatic operation by minimizing heat losses.
- Ease of access for sampling probes.

The experimental facility is suitable for the nitrogen and sulfur oxides studies currently in progress and is also suitable for investigations on particulate formation, slagging and fouling.

A functional schematic of the overall BSF is shown in Figure A-1. The relationship between the furnace elements and a typical utility boiler is indicated.

Figure A-2 is a schematic of the actual furnace showing the burners, air and sorbent injection locations, convective zones, and sample points. The functional elements of the BSF system include:

- Fuel Supply
- Sorbent Supply
- Air Supply
- Burner
- Furnace
- Clean-up
- Data Acquisition

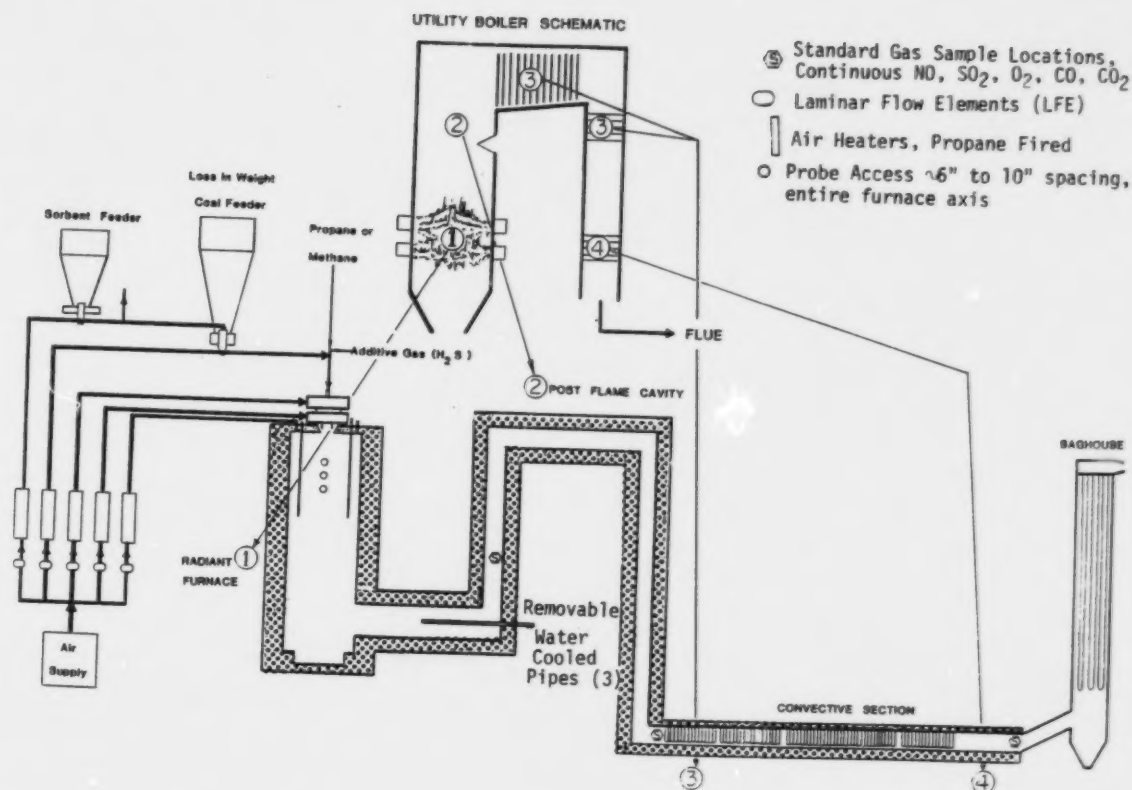


Figure A-1. Functional schematic of boiler simulator furnace.

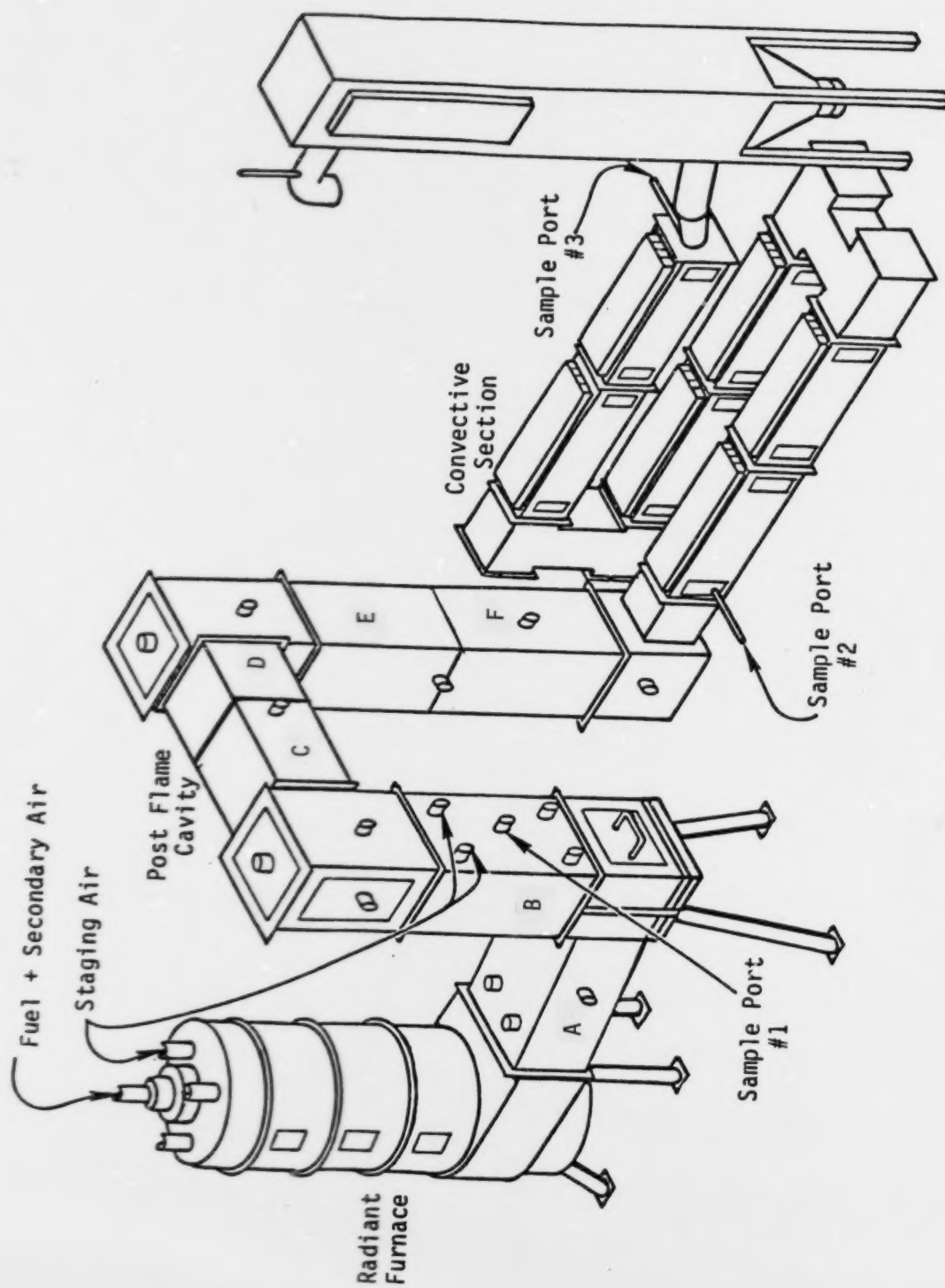


Figure A-2. Downfired boiler simulator furnace.

The fuel system has two subsystems: a coal supply system and a natural gas supply system. The coal is batch pulverized, stored under nitrogen in bins and delivered to a twin-screw, loss-in-weight feeder for metering to the burner. The coal is transported from the feeder to the burner with metered primary air. A removable nozzle is used to inject the coal-air mixture into the furnace. The furnace is fired with natural gas overnight to maintain the required thermal conditions. Gas or coal may be fired as needed for testing. Additive gases, such as H_2S or SO_2 may be added to the gas at the burner. These gases may also be added to the combustion air or to the coal primary air if required.

The sorbent may be added to the system in several ways: pulverized with the coal, added with the coal in the primary air, added with the staging air (either at the burner face or downstream) or added directly into the furnace with a small amount of transport gas (either air or nitrogen). The sorbent is fed with a small, twin-screw volumetric feeder. The sorbent is transported from the feeder to the injection location with metered gas (either air or N_2). Pressures at the feeder exit are regulated to prevent plugging of the delivery tube or aspiration of sorbent from the feeder. The coal and sorbent supply system are shown schematically in Figure A-3.

The combustion air is supplied by a dedicated 300 scfm, 100 psig capacity compressor. The air is cooled, dried, regulated to 45 psig and supplied to a 5 stream manifold. Each air stream is metered and controlled separately. Flow rates are indicated by pressure drops across laminar flow elements (read manually with inclined manometers and, for computerized on-line data acquisition, with pressure transducers). Each metered air stream flows through a natural gas fired recuperative air heater. The five air streams are used for: variable swirl, secondary air (axial and swirl air streams); primary (coal transport) air; tertiary or staging air; and sorbent transport.

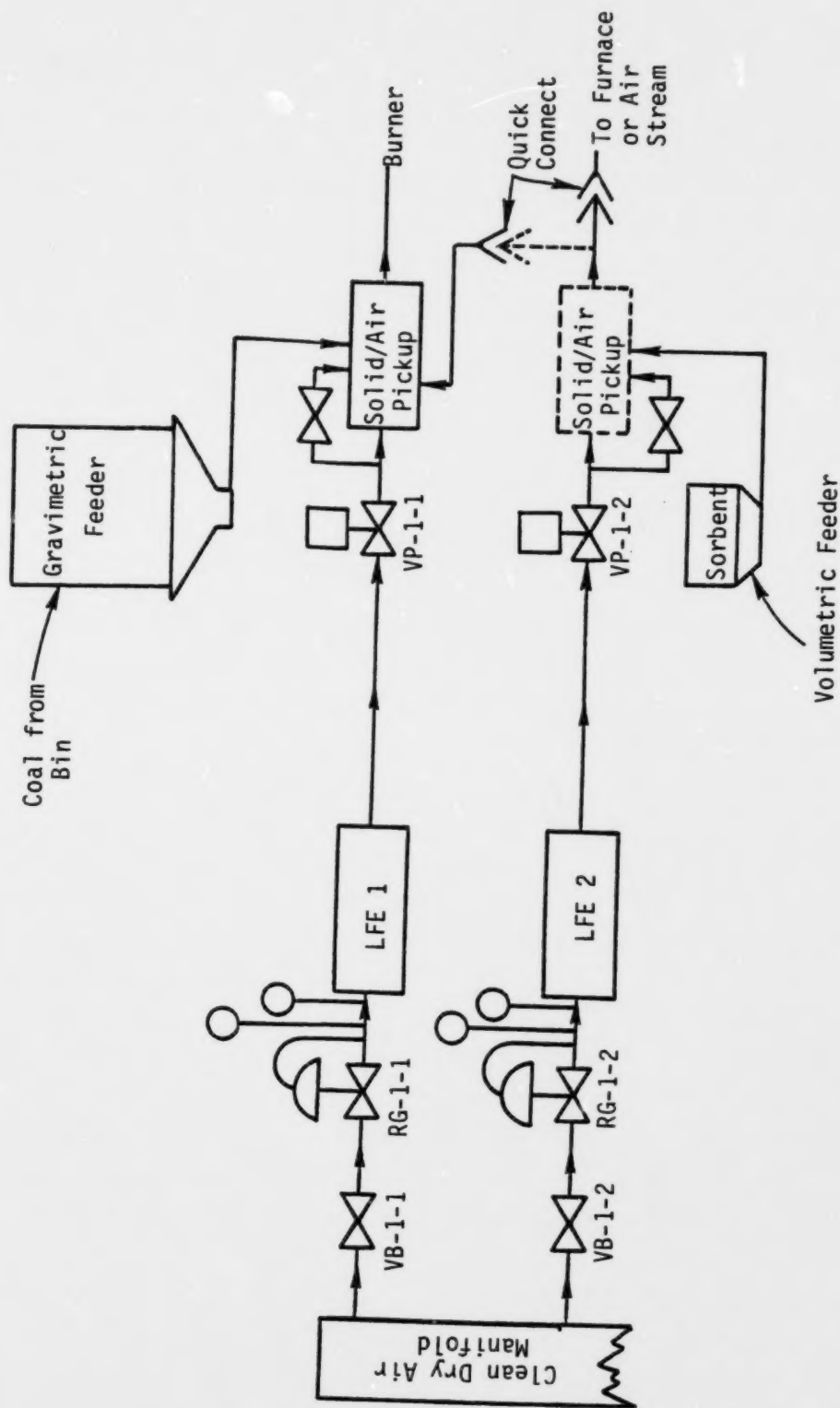


Figure A-3. Schematic of coal and sorbent feed systems.

A.2 Distributed Mixing Burner (DMB)

The furnace is equipped with a versatile DMB modeled after the EPA prototype burner. The burner is shown schematically in Figure A-4. Two secondary air streams are supplied to the burner. The secondary air swirl can be controlled by modifying the swirl and axial air flow rates. The burner has four external staging air ports supplied with separately metered tertiary air. The tertiary air injection velocity is modified by changing the air injector size. The burner is designed to fire coal or natural gas. Four fuel injectors are available: two coal injectors to supply the fuel in an axial core or radially spread by a divergent in the nozzle, and axial and radial natural gas injecting.

A.3 Furnace

The furnace is designed to simulate the time/temperature and velocity characteristics of coal-fired boilers and consists of the following components (see Figure 5-2):

- Radiant Combustion Zone
- Post-flame Cavity
- Convective Heat Exchange Sections - primary, secondary, and reheat superheaters
- Economizers and Air Heaters

The design specifications of these components are summarized in Table A-1.

A.3.1 Radiant Furnace

The cylindrical radiant combustion section is designed to simulate the region near the circular burners of a boiler where the flow is axisymmetric. The radiant section is made of four cylindrical modules three feet in

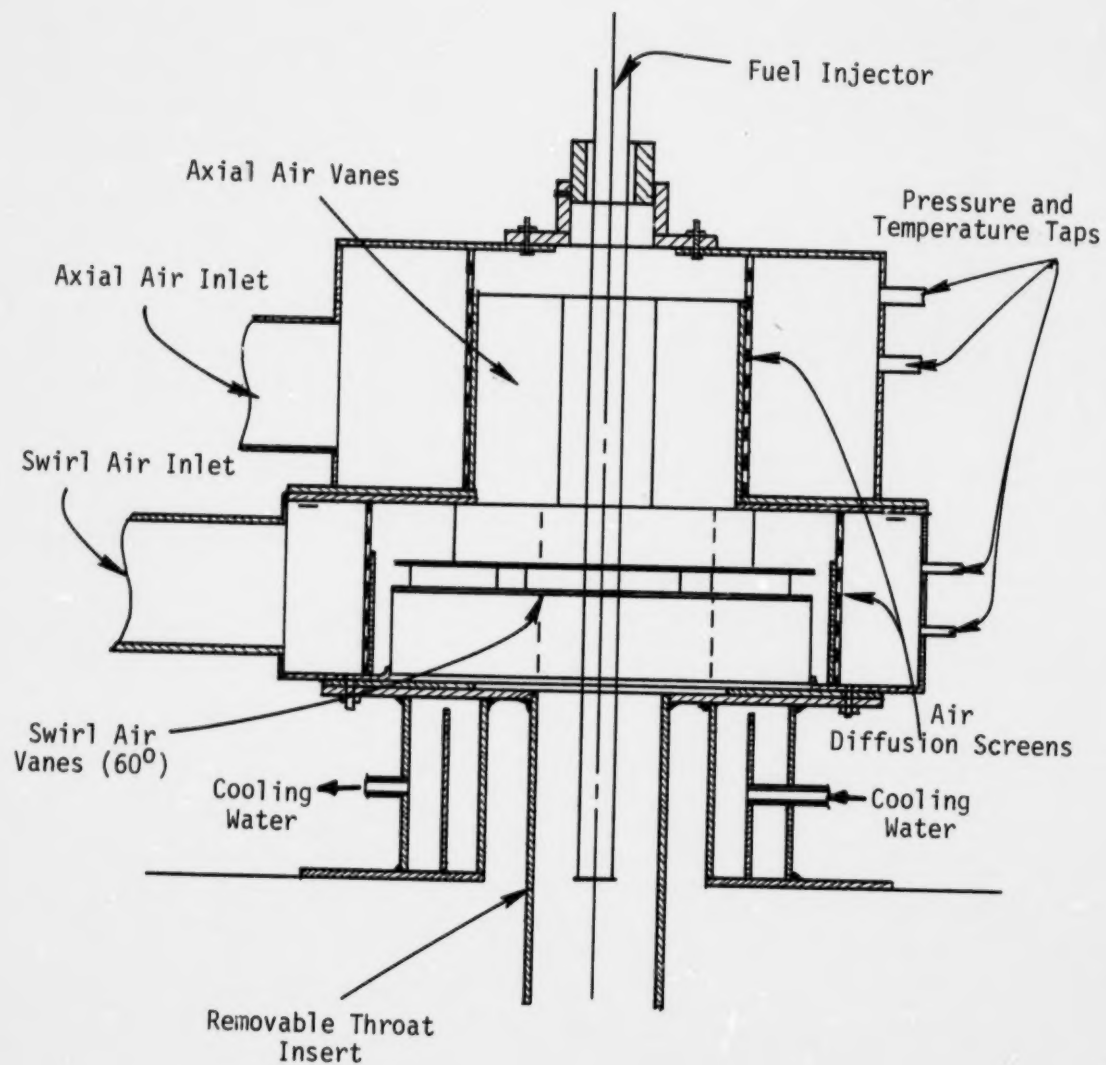


Figure A-4. Distributed mixing burner schematic, BSF (tertiary air ports not shown).

TABLE A-1. BOILER SIMULATOR FURNACE COMPONENT DESIGN SPECIFICATIONS

I. Radiant Section Design Specifications - General

Internal Dimensions	22" ID x 93" Long
Exernal Dimensions	36" OD x 96" Long
Orientation	Vertical
Maximum Designed Gas Temperature	3400°F
Furnace Volume	21.11 ft ³
Internal Surface Area	45.07 ft ²
Number of Modules	Four: One (1) Burner Module Two (2) Regular Modules One (1) Exhaust Module
Wall Construction	Adiabatic Modules and Exhaust Module Consisting of 4 Wall Layers (inside to outside): 3" AP Green Jade Ram Set 2" AP Green Castable 30 2" AP Green Castable 25 1/8" Carbon Steel Casing
Residence Time @ 1×10^6 Btu/hr SR _T = 1.2 T _{mean} = 2800°F	1.2 Seconds
Total Port Area/%	177 in ² /2.24%

TABLE A1

BOILER SIMULATOR FURNACE COMPONENT DESIGN
SPECIFICATIONS (CONT.)

II. TRANSITION, POST FLAME SECTION DESIGN SPECIFICATIONS - GENERAL

Transition Section Internal Cross Section Area, Section A	1.24 ft ²
Transition Section A Internal Length, Section A	56"
Internal Dimensions, Section B	18" x 12" x 75.42" Long
Internal Dimensions, Section C	18" x 112" x 54.56" Long
Internal Dimensions, Section D	12" x 14" x 55.63" Long
Internal Dimensions, Section E	12" x 12" x 54.0" Long
Internal Dimensions, Section F	8" x 10" x 54" Long
Orientation	See Figure A2
Maximum Designed Gastem Perature	2700 °F
Total Volume	30.036 ft ³
Total Internal Surface Area	118.12 ft ²
Wall Construction	Section A, and B
	Layers (Inside to Outside)
	3" AP Green 97
	3" AP Green 97L
	1/8" Carbon Steel Casing
	Section C and D
	Layers (Inside to Outside)
	3" Mizzau Castable
	1" M50 Blue Insulation
	1" M50 Blue Insulation
	1" K19 Insulation
	Section E and F
	4" Green Cast K30
Residence Time At: 1 x 10 ⁶ BTU/hr SRT = 1.2 TiN 2600 °F T out 1800 °F	1.6 ru
Total Post Area/%	866 in ² /5.09%

TABLE A-1. BOILER SIMULATOR FURNACE COMPONENT DESIGN SPECIFICATIONS (CONT.)

III. Superheater/Reheater Design Specifications - Active Heat Transfer Tube Bundles

	Superheater	Reheater
Tube Arrangement	Cross Flow Banks	Cross Flow Banks
Tubing Size	3/8"	3/8"
Wall Thickness	0.035"	0.035"
Tubing Spacing Perpendicular to Flow	2.0"	2.0"
- Parallel to Flow	0.85"	0.85"
Number of Rows	148	148
Tube Length per Row	31"	27"
Total Length	382 ft	333 ft
Total Exchange Surface Area	37.5 ft ²	32.7 ft ²
Estimated Heat Transfer Coefficient	7.1 Btu/hr-ft ² -°F	7.1 Btu/hr-ft ² -°F
Estimated Heat Extraction Rate	472,000 Btu/hr	250,400 Btu/hr
Cross-Section Area of Tube	11.6 in ²	10.1 in ²
Free Flow Area (gas side)	52.4 in ²	38.9 in ²
% Tube Area	18.2%	20.6%
Gas Velocity	41 ft/sec	39 ft/sec
Estimated Residence Time	0.34 sec	0.37 sec

TABLE A-1. BOILER SIMULATOR FURNACE COMPONENT DESIGN SPECIFICATIONS (CONT.)

IV. Air Heater Design Specifications - Active Heat Transfer Tube Bundles

Tube Arrangement	Cross Flow Banks
Tube Size	3/8"
Wall Thickness	0.035"
Tube Spacing Perpendicular to Flow	2.0"
- Parallel to Flow	0.85"
Number of Rows	148
Length per Row	23"
Total Tube Length	284
Total Tube Surface Area	27.8 ft ²
Estimated Heat Extractions Rate	7.1 Btu/hr-ft ² -°F
Estimated Heat Extractions Rate	109,000 Btu/hr
Cross-Section Area of Tube	8.6 in ²
Free Flow Area	27.4 in ²
% Tube Area	23.9%
Gas Velocity	34 ft/sec
Estimated Residence Time	0.58 second

TABLE A-1. BOILER SIMULATOR FURNACE COMPONENT DESIGN SPECIFICATIONS (CONT.)

V. Air Heater Design Specifications - General

Internal Dimensions	8" x 6" Section x 14'0"
External Dimensions	14" x 14" Section x 14'0"
Total Volume	4.67 ft ³
Internal Surface Area	32.7 ft ²
External Surface Area	65.3 ft ²
Orientation	Horizontal
Design Gas Temperature	850 F - 250 F
Wall Construction	3" Thick Castablock
Module	2 - Adaptor = 1' long 2 - Regular = 6' long
Nominal Conduction Heat Transfer Coefficient	0.50 Btu/hr-ft ² -of
Estimated Heat Loss	235 Btu/hr-ft ²
Estimated Total Conduction Heat Loss	7,700 Btu/hr
Estimated Residence Time	0.58 second
Estimated Weight	800 lb

diameter and two feet long. A typical module is shown schematically in Figure A-5.

A.3.2 Post-Flame Cavity

The post-flame cavity was required to:

- Provide a reaction volume similar to the space above the burner zone in a boiler.
- Create a region where the bulk gas velocity is similar to that of the gases leaving the active burner zone, hence, simulating bottom-ash deposition.

The post-flame cavity has an arch (internal refractory shape) from the radiant furnace, is approximately 30 feet long and has a cross-sectional area which decreases stepwise from 18" x 12" to 10" x 8".

A.3.3 Convective Section

A horizontal duct 14 feet long of inlet cross-section 8" x 8" and with active convective heat transfer tubes simulates the primary superheaters. The reheat superheater is similar in design, but has an 8" x 7" internal flow section. The economizer and air heater sections differ from the superheaters in their operating temperatures and construction as indicated in Table A-1. The heat transfer tubes are air-cooled and arranged at 90° to the direction of gas flow. Varying the coolant flow rates controls the rate of heat removal in each convective section. All of the convective sections are insulated to minimize uncontrolled heat losses. A schematic of a convective section is shown in Figure A-6.

During the program testing two of the tube bundles in the convective section (the primary superheater and reheat superheater cooling tubes) wore out and developed leaks. Two new convective sections, with 8" x 8" cross-section and altered cooling tube design were constructed and installed. The

Dimensions: Inches

Left Side

Section CC

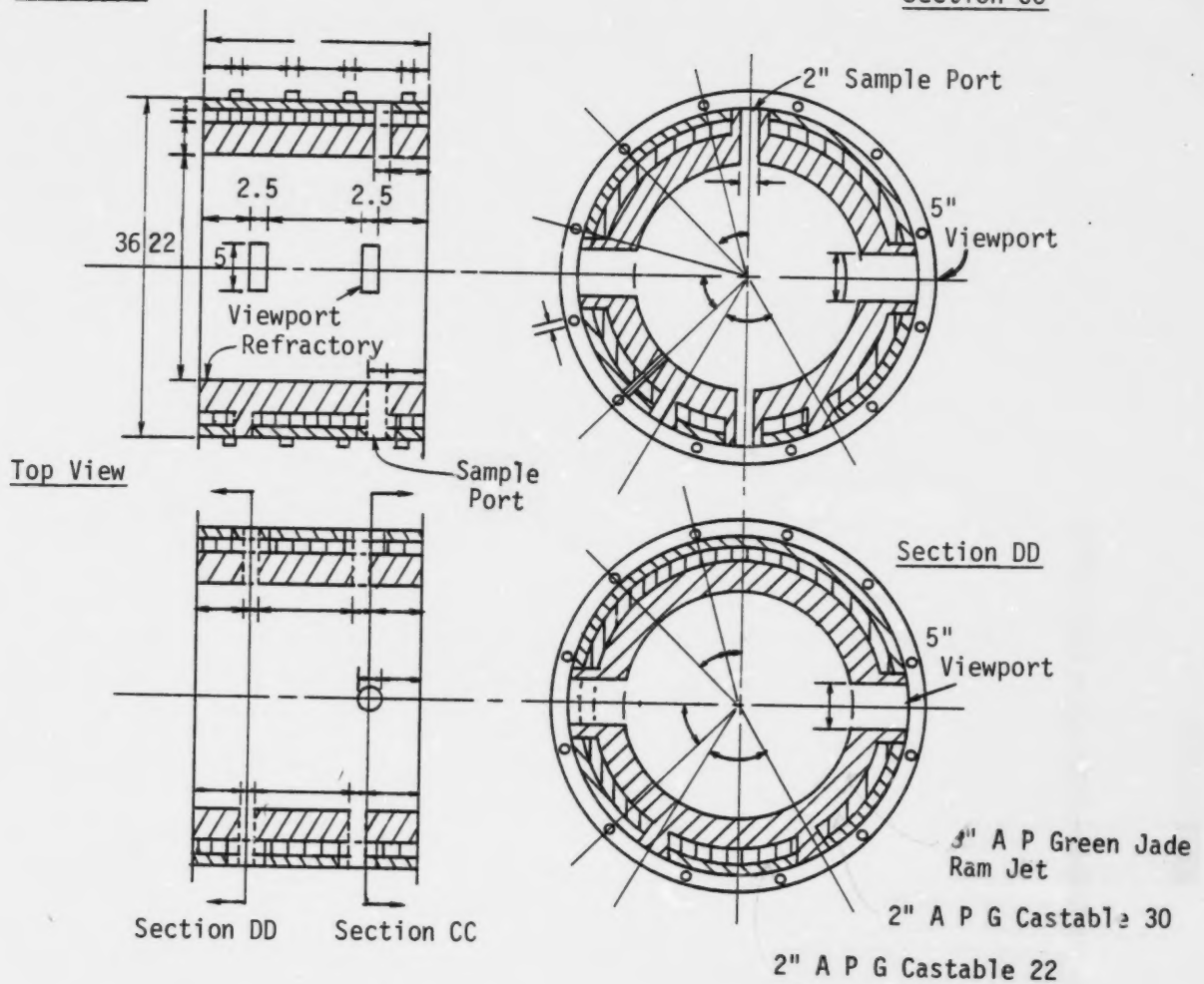


Figure A-5. BSF - radiant adiabatic furnace module - concept.

Dimensions: Inches

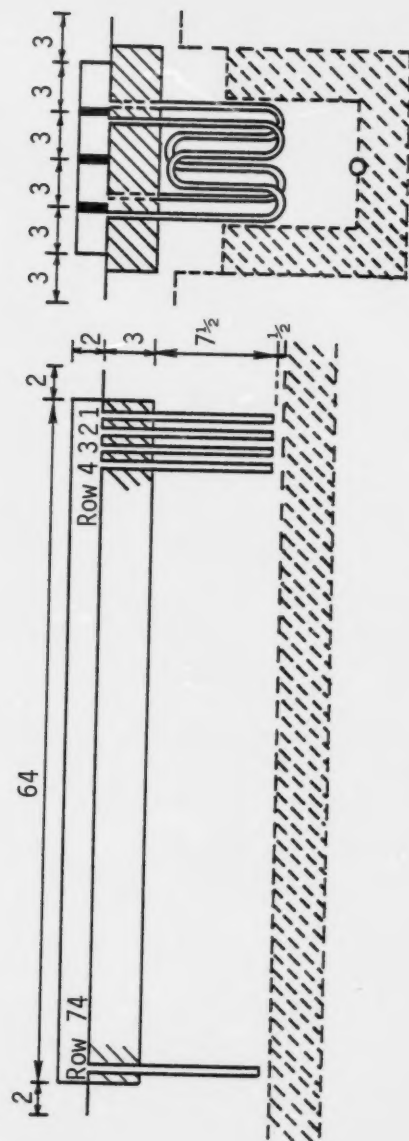


Figure A-6. BSF - convective air-cooled superheater model.

convective section design was changed to facilitate the removal of ash deposits and repairs of leaking tubes. Operating experience (including heat transfer data and fouling measurements) in the BSF and other furnaces was used to specify design criteria. The design criteria and heat transfer calculations are summarized in Table A-2. Figure A-7 is a schematic of the tube bundle design and Figure A-8 shows the convective section housing and layout of the tube bundles. Two convective sections, with five tube bundles each, were installed to replace the damaged sections. Figure A-9 shows temperature profiles through the convective sections before and after the two sections were replaced.

A.4 Temperature Profiles - Cooling

A key design feature of the BSF is the ability to "tailor" the thermal history of the sorbent and combustion products. The temperature profile in the convective sections is controlled by controlling the coolant flow rates (as discussed above). Upstream, the furnace is designed to minimize heat losses to the atmosphere. The thermal history in the radiant and post-flame cavities is modified with removable cooling coils (in the radiant furnace) and pipes (in the radiant post-flame transition). Various heat extraction levels are possible using these coils and rods.

A.5 Ash Handling

A typical bituminous coal will produce about 8 lb/hr of ash when fired at the BSF nominal load of 1.0 MBtu/hr. The ash loading will increase with sorbent injection or increased coal ash loading. Deposition of slag and ash on the radiant and post-flame walls cannot be avoided. Molten slag runs down the furnace walls into a removable refractory-lined slag trap at the base of the radiant furnace. The slag trap is changed for an empty trap as needed.

A.5.1 Fly Ash - Baghouse

Fly ash which passes through the furnace is collected from the exhaust in a baghouse. The baghouse is equipped with special fabric bags which will

TABLE A2. CONVECTIVE SECTION DESIGN CALCULATIONS

CONVECTIVE SECTION NO.2 - MODIFICATION

Design Basis:

Overall Heat Transfer Coefficient	=	7 $\frac{\text{Btu}}{\text{Hr-Ft}^2 - ^\circ\text{F}}$
Overall Heat Removed (Nominal)	=	45,000 Btu/hr
T _{gas Inlet}	=	1550°F
T _{gas Outlet}	=	1230°F
T _{air Inlet}	=	80°F
T _{air Outlet}	=	700°F
Log Mean ΔT	=	992°F

Hardware Specification:

Outside Tube	=	SS304, 2" OD, 0.035" Wall
Inside Tube	=	SS304, 1-3/4" OD, 0.035" Wall
No. of Tubes	=	20
Length of Exposed Tube	=	7-1/2"
Total Tube Length	=	10-1/2"
Tube Area Exposed	=	6.55 Sq. Ft.
Total Flow Area	=	0.158 Sq. Ft. Outside

Operation:

$\dot{m}$ air	=	380 lb/hr total
$\dot{v}$ air @ 70°F	=	85 SCFM
$\dot{v}$ air @ 700°F	=	186 CFM
Tube Air Velocity	=	15.5 ft/sec Outside
	=	7.7 ft/sec Inside

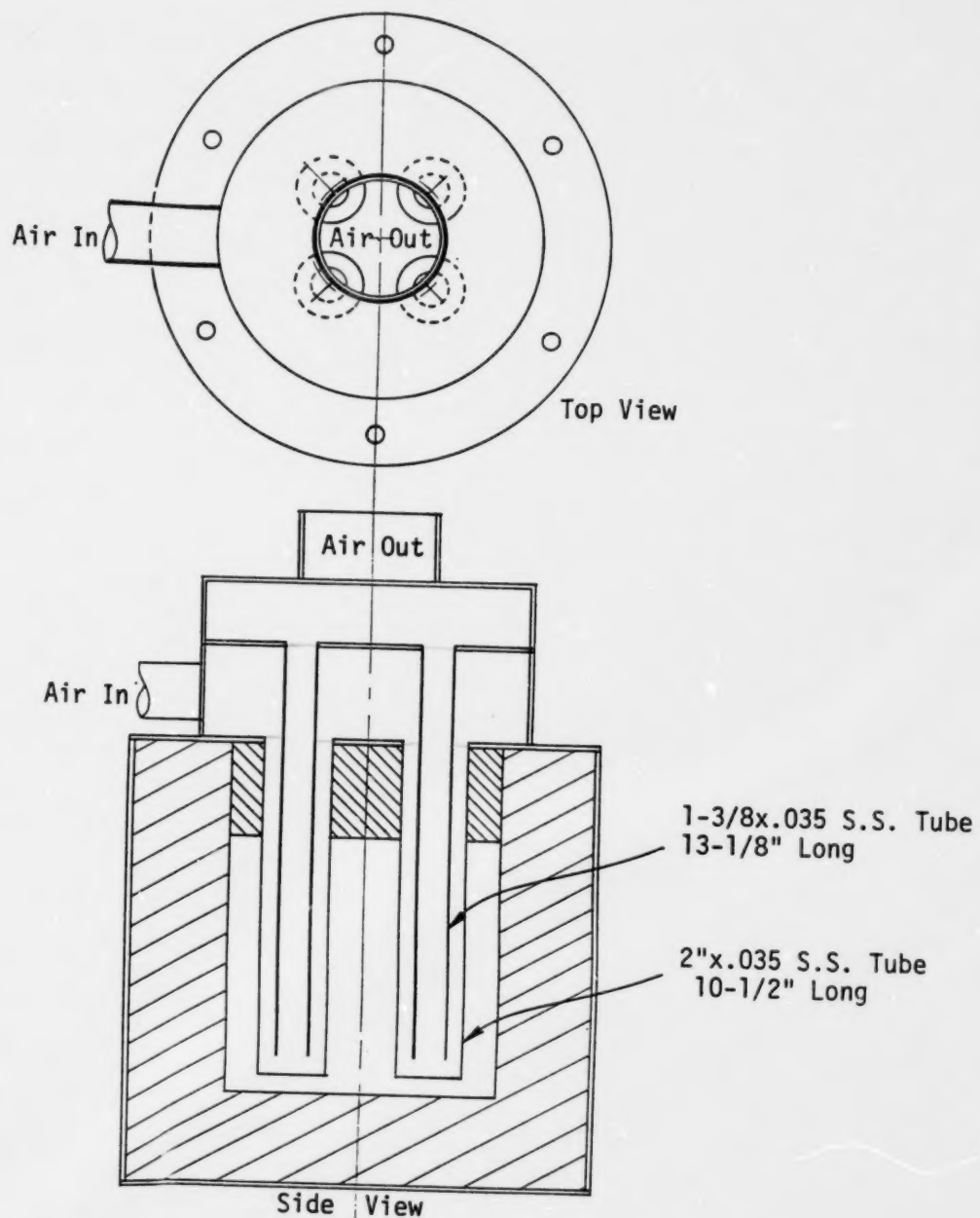


Figure A-7. Convective section tube bundle schematic.

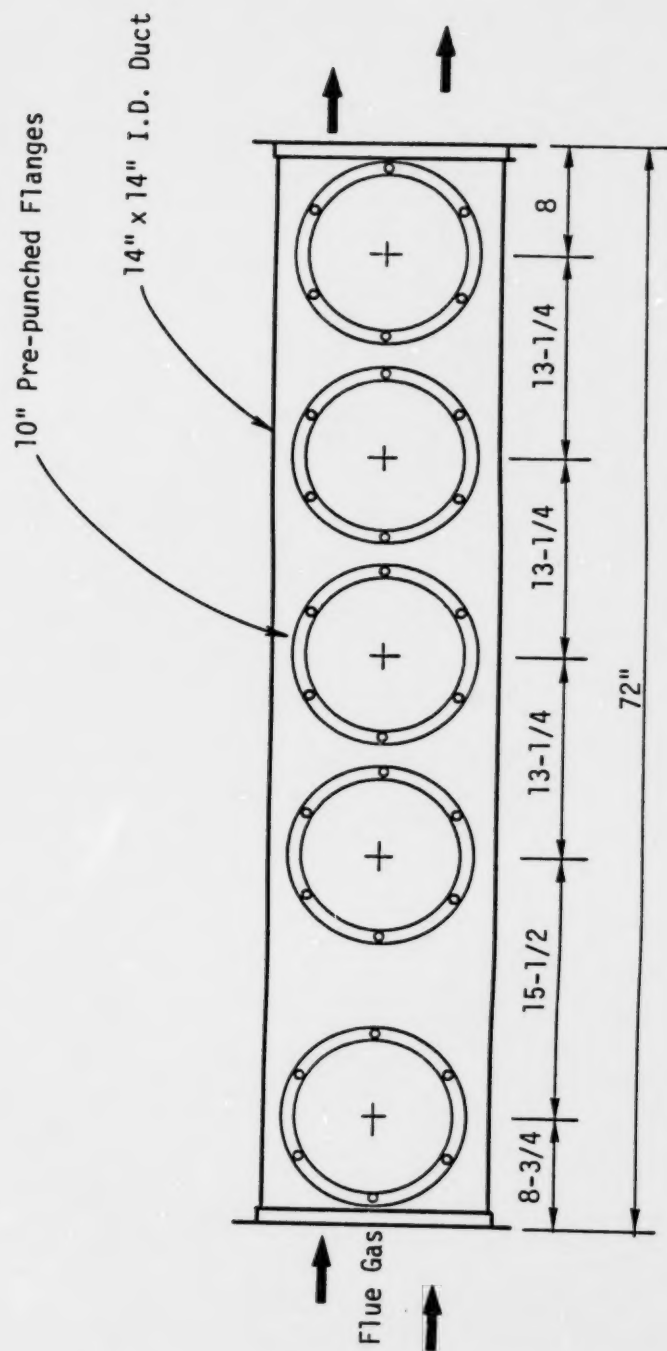


Figure A-8. Schematic of convective section, housing, top view.

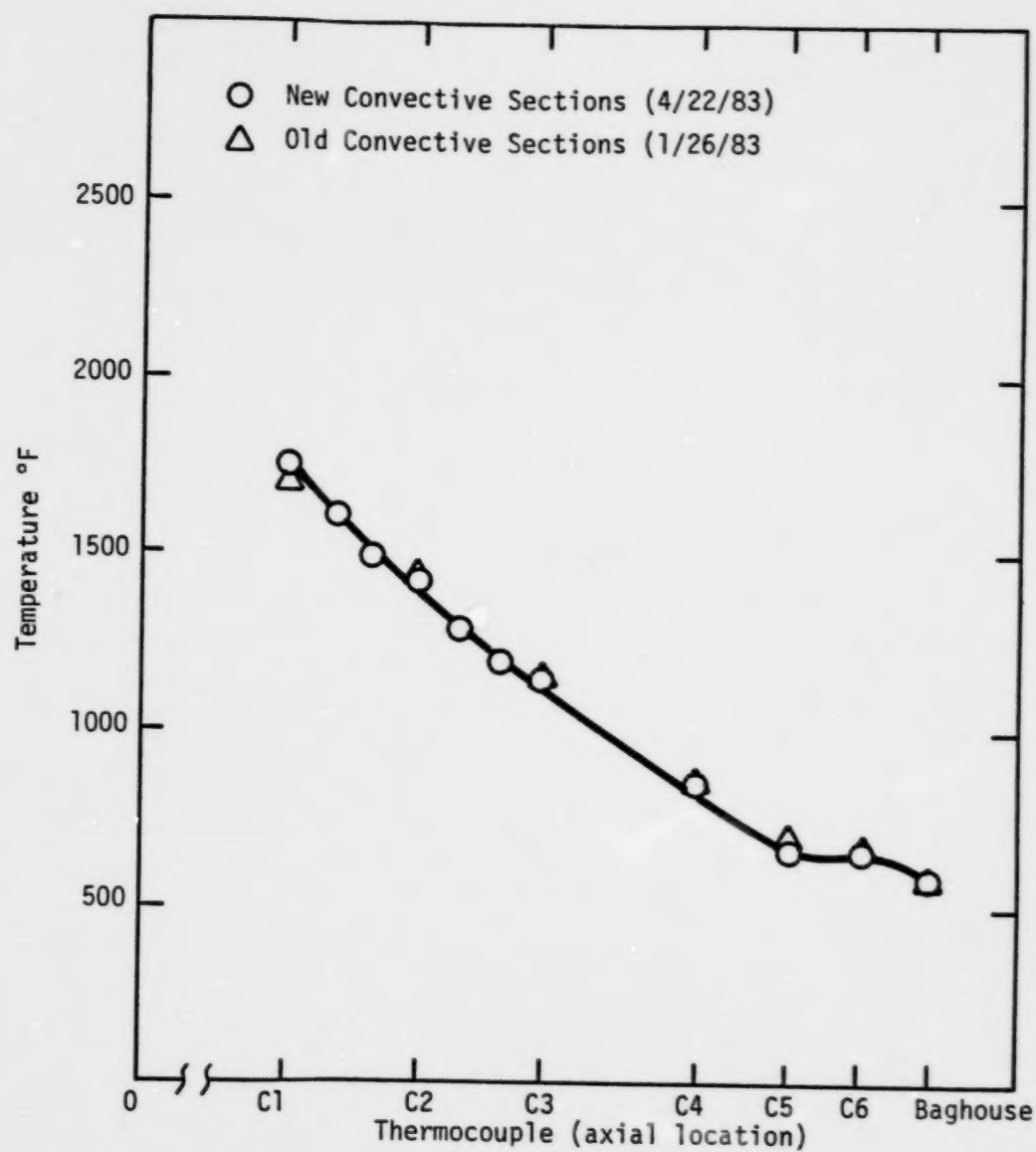


Figure A-9. Comparison of temperature profile through convective sections (redesigned is "new" section).

allow high temperature (to 50°F) operation when needed. The baghouse is exhausted with an induced draft fan and the clean exhaust gas is discharged. The ID fan is equipped with a damper and the furnace/convective sections are generally run at ambient or slightly (up to 6" H₂O at the burner) positive pressure to prevent dilution by in-leakage of air.

A.6 Data Acquisition

The BSF is very complex; numerous variables such as:

- input parameters including fuel and air flow rates and temperatures, coolant temperatures and rates;
- output parameters including gas product concentrations and temperatures;
- system operational parameters including furnace temperatures, pressures and ancillary equipment (i.e., compressor, fans, cooling tower) operation;
- computed "performance" parameters such as mass and energy balances, pollutant formation rates, and bulk gas velocities and residence times;

are monitored on a continuous basis. A computerized on-line data acquisition system is used to help monitor and record system operating parameters. All of the experimental and data acquisition procedures may proceed without the computer. (Sample gas compositions, fuel and air flow rates, furnace temperatures and pressures, etc., can all be read and recorded manually if necessary.)

APPENDIX B-- MEASUREMENTS

Measurements performed as part of this experimental program included:

- Gaseous species concentrations;
- Solids composition and physical characteristics;
- Furnace and gas temperatures;
- Fouling measurements
- Fly ash characterization

Table B- 1 summarizes the gas and solid species measured and the solid characteristics determined. The methods and instruments used for these measurements are listed, as are the probes and sample conditioning systems used to obtain samples. This section describes the standard sampling and analytical systems used for the bench-scale studies, including the development and testing of a probe and sample conditions system for sulfur species measurement.

B.1 Gas Samples

The measurement of sulfur species in combustion products containing active sorbents poses several special problems. Sulfur species are water soluble and highly reactive with calcium-based sorbents. It is imperative that gas-solid contacting be minimized and contact between the gas and any condensed water be avoided. Therefore, a phase "discriminating probe" for the measurement of sulfur species was designed, constructed and tested. The probe is designed so that the sulfur species sample is extracted from the main particle-laden sample steam at right angles to the main flow and at a relatively low velocity (see Figure B-1). The probe supplies two gas streams simultaneously: the main, particle-laden stream which is used for continuous monitoring of O_2 , CO , CO_2 , NO_x and the side, nearly particle-free,

TABLE B-1. MEASUREMENTS

MEASUREMENT	PROBE AND CONDITIONING	ANALYTICAL METHOD/INSTRUMENT
<u>Gases</u>		
O ₂	Standard or Phase Discrimination - Continuous	Beckman 755
CO ₂		Non-dispersive Infrared (Anarad) AR-600R
CO		Non-dispersive Infrared (Anarad) AR-500R
NO _x		Chemiluminescent (TECO)
SO ₂	Phase Discrimination, Continuous	Non-dispersive Ultraviolet (DuPont) 400 Photometric Analyzer
<u>Temperatures</u>		
Furnace	Wall Thermocouples Suction Pyrometer	Type S or K Thermocouple
Gas		Type S or B Thermocouple
<u>Solids</u>		
Mass Loading	Isokinetic Solids Probe or Grab Sample with Glass Cyclone	Mass Basis, Ash as Tracer
Carbon		CO ₂ Evolution, Combustion (Perkin-Elmer 240B)
Hydrogen		H ₂ O Evolution Combustion
Nitrogen		N ₂ Evolution Combustion
Oxygen		
Sulfur		SO ₂ Evolution (Leco)
Ash		Combustion
Heating Value		ASTM
CaO		
Size Distrib.		Sedimentation
Surface Area		N ₂ Adsorption BET (Quantachrome)
Hydration Wt.Gain		H ₂ O Uptake
Dissolution Rate		Acid Titration

Dimensions: Inches

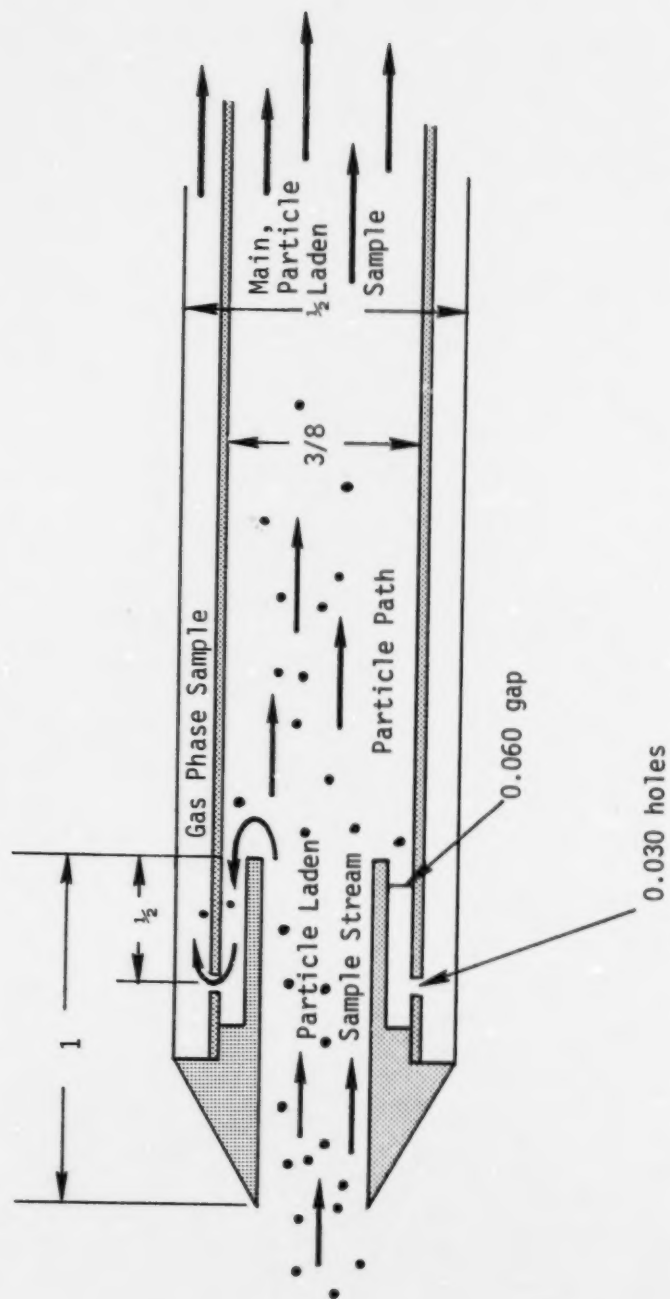


Figure B-1. Phase discrimination probe.

stream which is used for SO₂ measurement. Sample conditioning for the two streams is somewhat different (see Figure B-2). The main sample (O₂, CO, CO₂, NO_x) is dried using an iced-condenser, filtered, pressurized, filtered again and delivered to the continuous instrumentation listed in Table B-1. The SO₂ gas sample is transported in a heated Teflon line maintained above 115°C under vacuum to a heated filter followed by a permeation tube drier. The permeation tube drier selectively removes water-vapor from the gas sample. Dry air is used as the dry gas medium in the permeation drier. The sample is then pressurized and delivered to the analytical system (see Figure B-3). SO₂ concentration is measured using a non-dispersive ultraviolet instrument manufactured by DuPont. The NDUB system was selected for simplicity, lack of interferences or quenching (a problem with pulsed-fluorescent SO₂ instruments) and linearity. The permeation drier was tested to assure that it did not pass SO₂, CO, CO₂, NO or O₂ across the semi-permeable membrane. The water removal efficiency of the drier was also demonstrated. Figure B-4 compares SO₂ concentrations without water-vapor and after water-vapor had been added to the gas and then removed in the permeation drier.

The sulfur measurement system was tested to ensure that observed SO₂ reductions with sorbent injection were due to reactions occurring in the furnace rather than to reactions in the probe/sample system. The system was tested under conditions where the sulfur capture was high (in other words, where the sorbent particles were very reactive). The sample system was tested by injecting SO₂ just before the sample probe. If the reaction occurs in the furnace SO₂ injected immediately before the probe will not react with sorbent and a pulse of sorbent will not change the measured SO₂ concentration. Because the Boiler Simulator Furnace (BSF) consistently exhibited a "profile" of SO₂ capture - capture at the exit of the radiant furnace was less than total capture at the exit of the post-flame section which, in turn, was less than capture at the exit of the convective sections - the measurements test was performed at all three sample locations. SO₂ was injected shortly ahead of each probe and measured at the probe (and at each downstream probe) while the sorbent was pulsed on and off. Figure B-5 shows the SO₂ injection and sample locations.

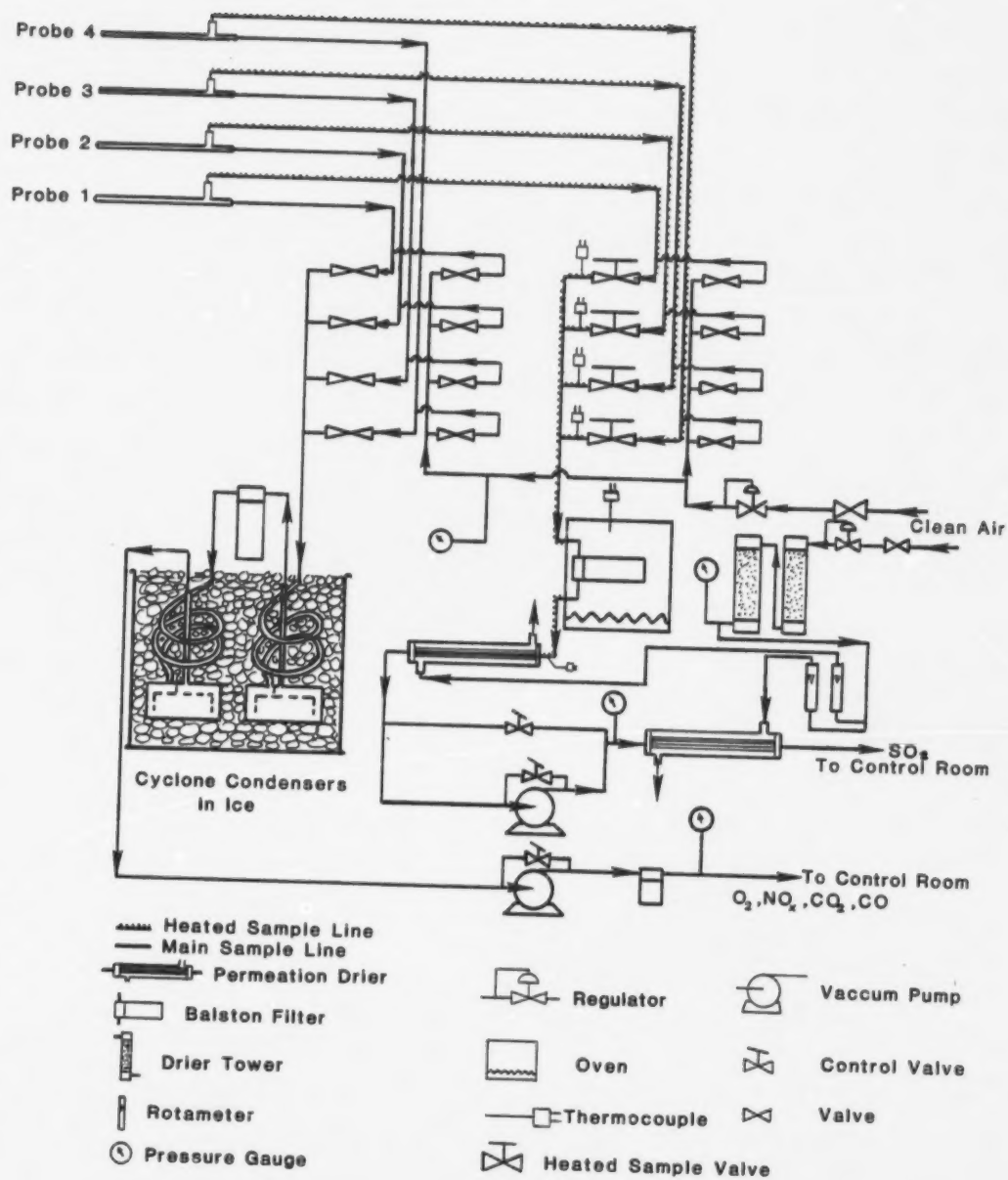


Figure B-2. Gas sampling system.

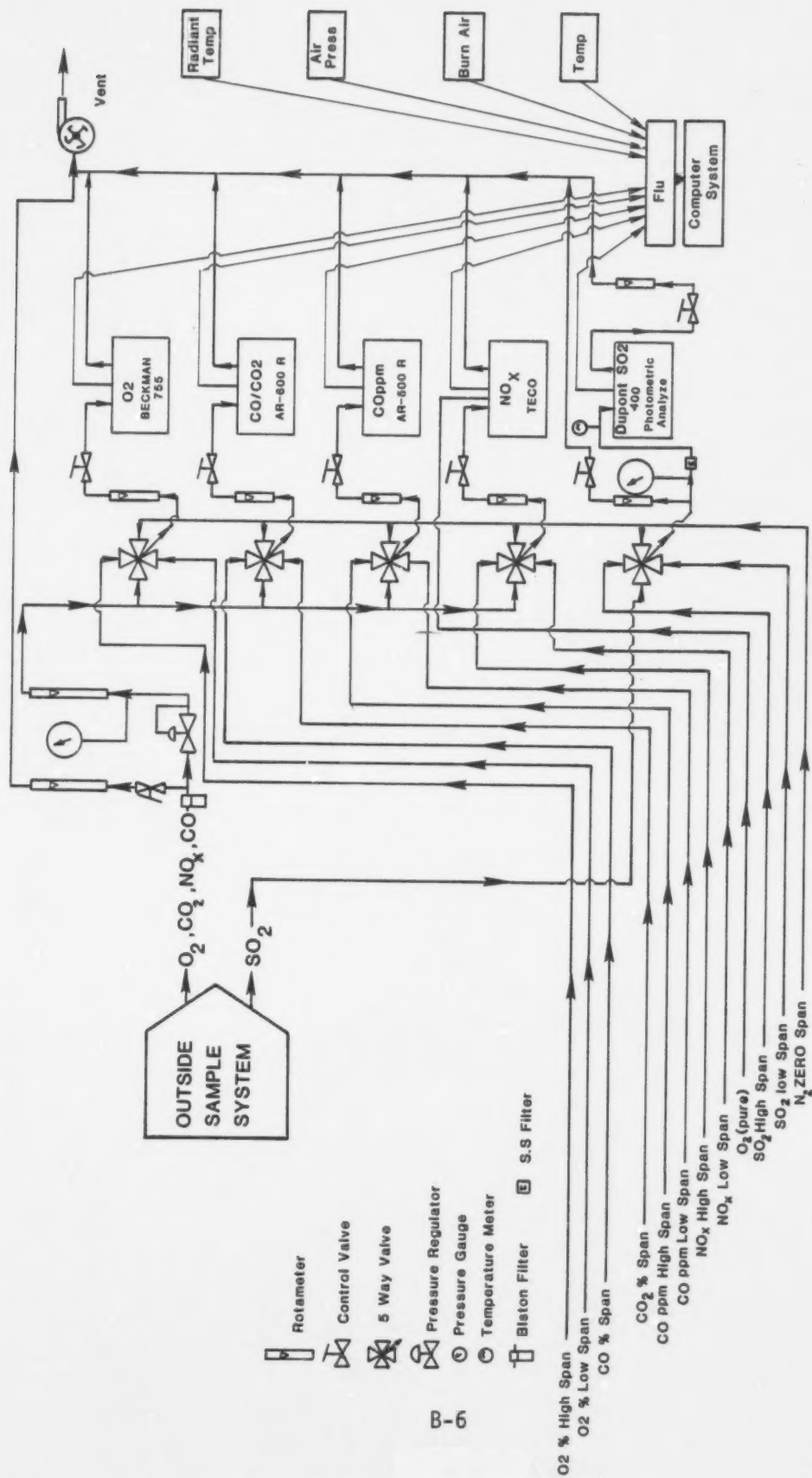


Figure B-3. Analytical system for gases.

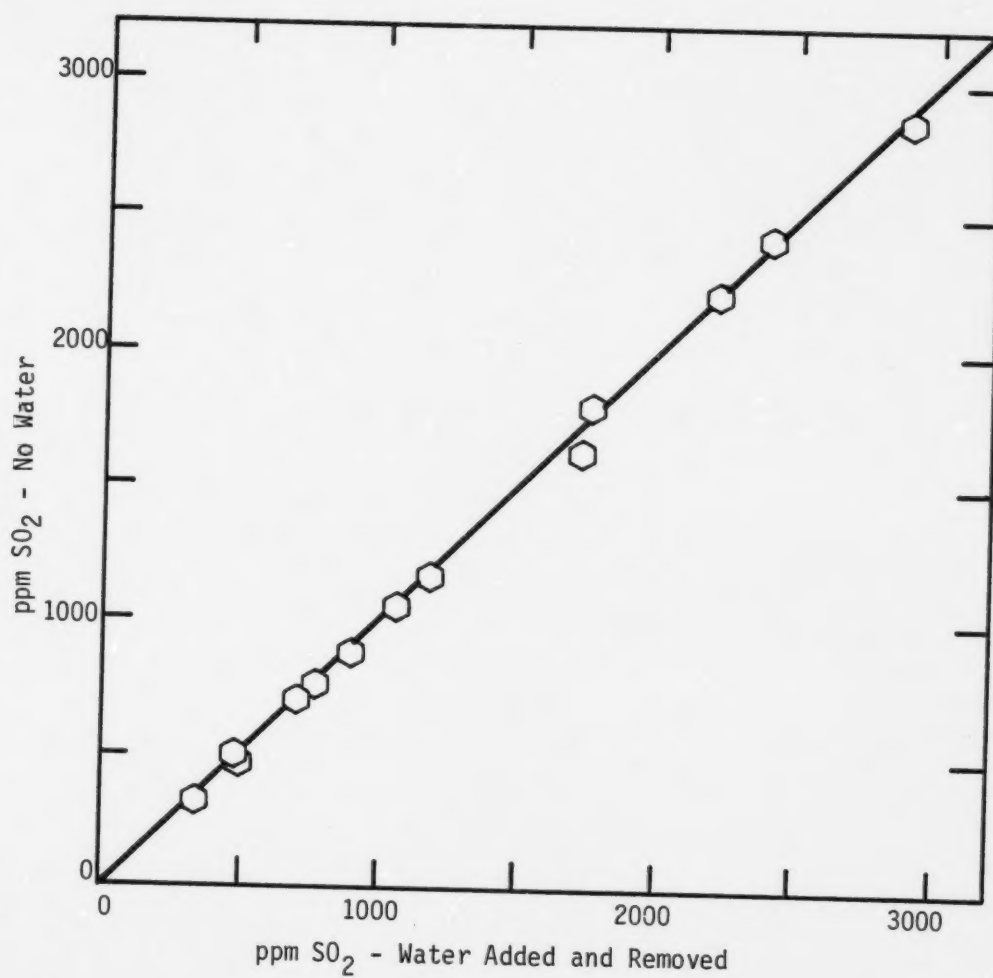


Figure B-4. Verification of permeation tube drier.

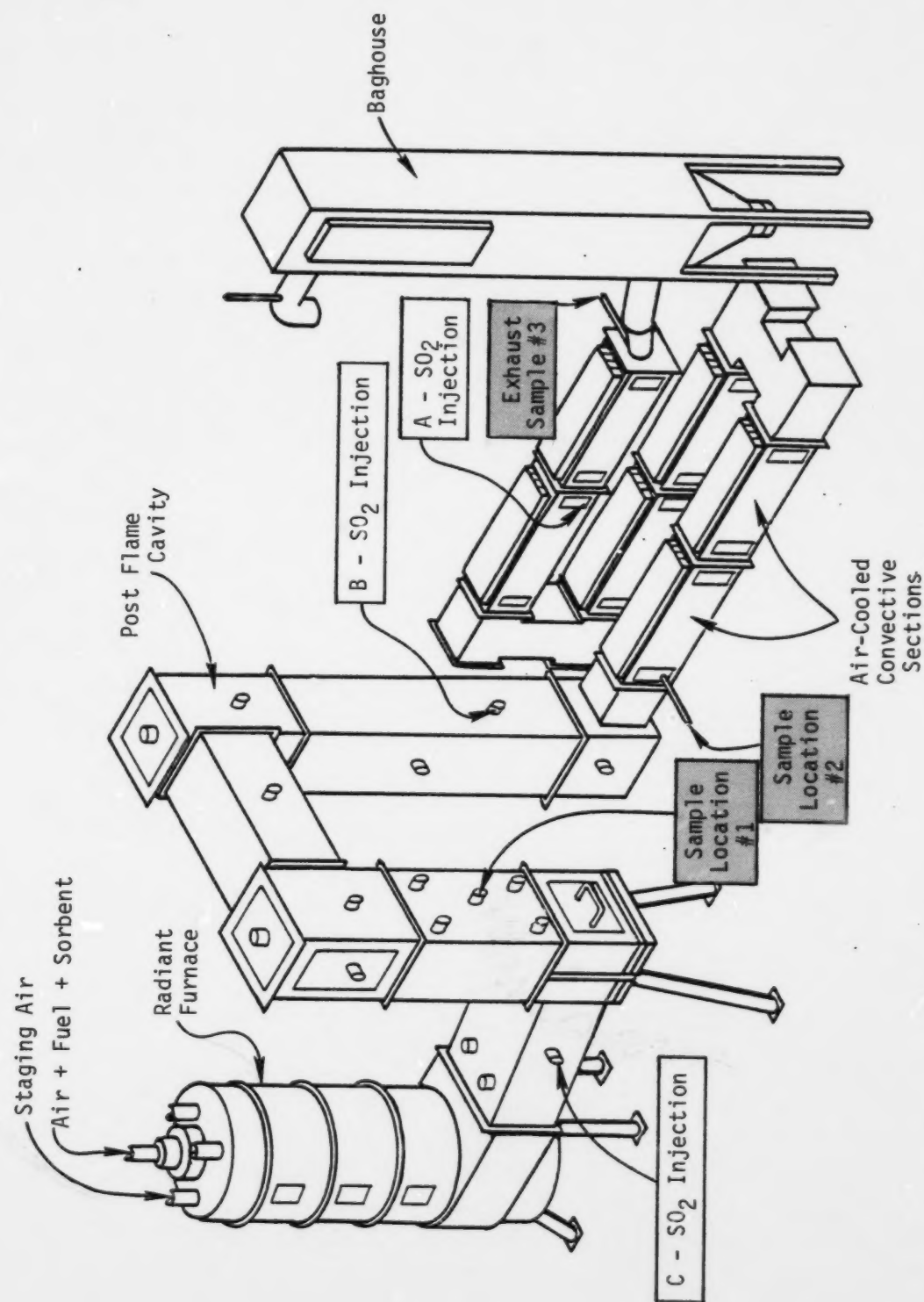


Figure B-5. Schematic of Boiler Simulator Furnace; S0₂ injection and sampling locations.

Figure B-6 is a trace of the actual SO₂ instrument response to a pulse of sorbent (added with the natural gas) when the SO₂ was injected just before Probe 3 (location A) and measured at Probe 3. It is clear that no sulfur capture is occurring in the sample system under these conditions. Figure B-7 shows the response at Probe 2 (B-7a) and at Probe 3 (B-7b) to a pulse of sorbent when the SO₂ was injected before Probe 2 (location B). The change in SO₂ measured at Port 2 (immediately after the SO₂ injection) was small (Figure B-7a). The measured sulfur capture at Port 3 (where the sorbent and SO₂ had significant furnace reaction time available) was considerably higher (see Figure B-7b). Figure B-8 shows the effect of a pulse of sorbent on the SO₂ measured at each of the three probes when the SO₂ was injected before Port 1 (injection location C). Figure B-8a shows the response at Port 1 to a pulse of sorbent. Figures B-8b and B-8c show the response at Ports 2 and 3. The SO₂ injection location and sorbent injection location were not changed. Again, little change in SO₂ due to sorbent injection was observed with the sample probe located immediately behind the SO₂ injection location. Significant levels of sulfur capture occurred in the post-flame cavity (sampling at Port 2) and in the convective passages (sampling at Port 3). These measurement tests indicate that the observed sulfur capture is indeed occurring in the furnace and not in the sample system.

B-6
B-7
B-8

After the gas samples were extracted from the furnace and conditioned they were delivered to a set of continuous analytical instruments (Table B-1). The instruments used were selected for reliability, ease of operation and cost. There is considerable experience at EER with standard CO, CO₂, O₂, and NO_x instrumentation. This experience was drawn on in selection and setup of the particular instrumentation with little effort spent on new developments. Continuous measurement of SO₂ was made with a non-dispersive ultraviolet instruments manufactured by DuPont. SO₂ is measured by the difference in absorption of ultraviolet radiation by the sample gas at two wavelengths - a reference wavelength and at 320 nm which is absorbed specifically by SO₂. The NDUV instrument was chosen in preference to a pulsed fluorescent instrument because of the linearity and stability of the DuPont and because there is not interference from H₂O, CO₂, or O₂ as there is (due to quenching of the fluorescence) in the pulsed fluorescent instrument.

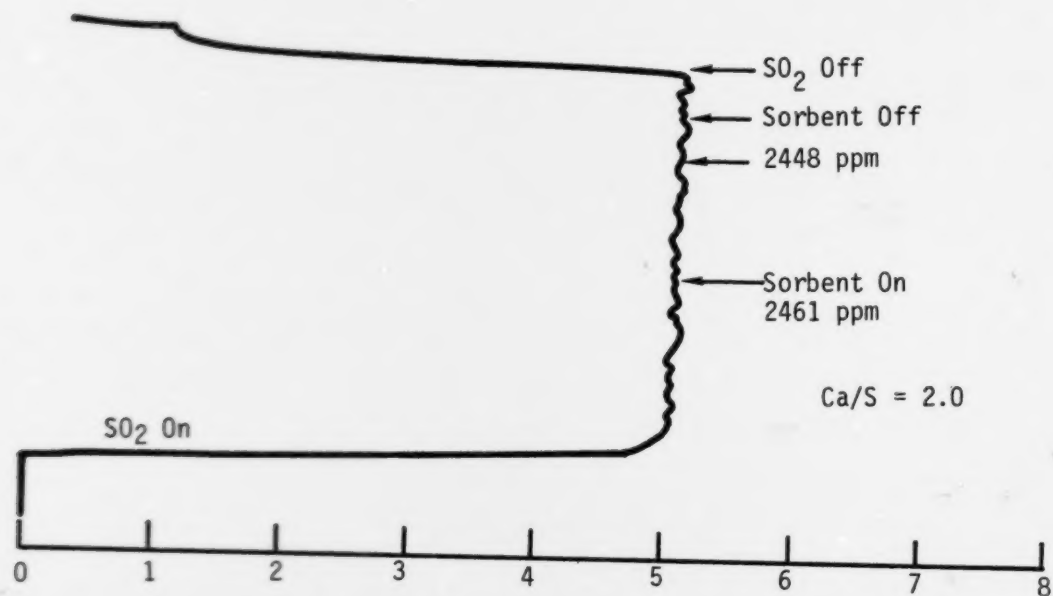
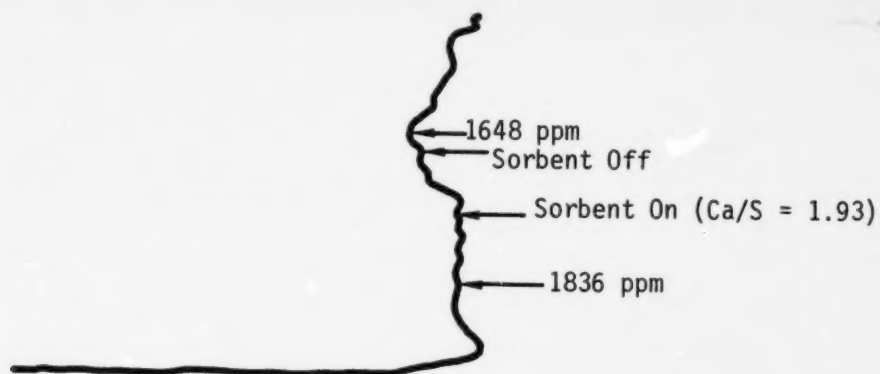
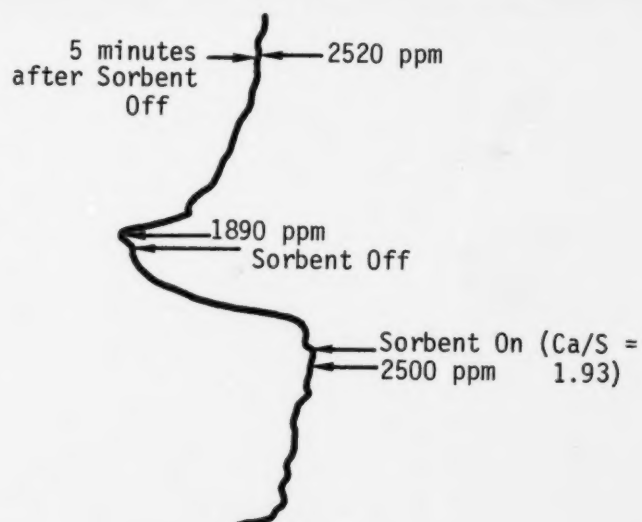


Figure B-6. Measurement system test; SO₂ injection at convective section (Location A), measured at probe 3.

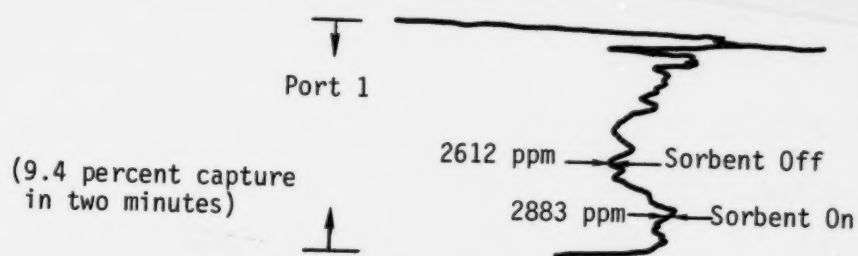


a. SO₂ Injected at B, Measured at Port 2

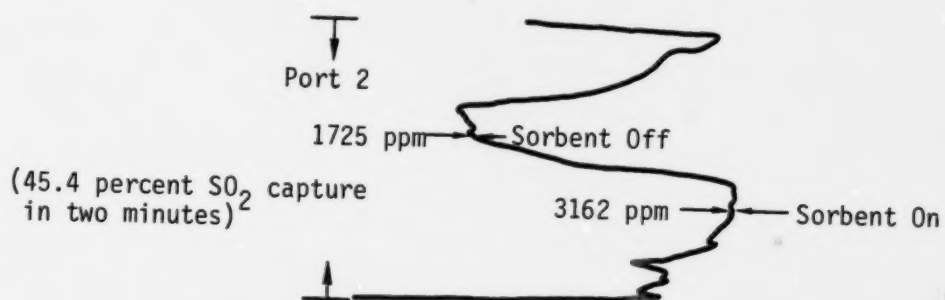


b. SO₂ Injected at B, Measured at Port 3

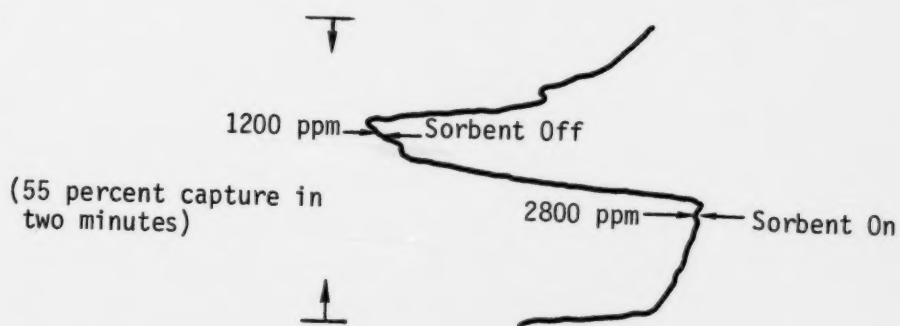
Figure B-7. Measurements system test; SO₂ injection at post flame cavity (Location B), measured at Port 2 and at Port 3



a. SO_2 Injected at C, Measured at Port 1



b. SO_2 Injected at C, Measured at Port 2



c. SO_2 Injected at C, Measured at Port 3

Figure B-8. Measurement system test; SO_2 injected at entrance of postflame cavity.

The DuPont instrument and sampling system were compared with EPA Method 7 SO₂ measurements under both cold (SO₂ + air) and flame conditions. The agreement was good and was not affected by water vapor content or SO₂ concentration.

The DuPont instrument is suitable for measurement of SO₂ in combustion stack gases, but aromatic and unsaturated hydrocarbons absorb U.V. light in the same wavelengths as SO₂; therefore, the DuPont cannot be used to directly measure SO₂ in fuel-rich combustion gases.

Wet measurements of SO₂ and SO₃ using controlled condensation followed by hydrogen peroxide scrubbing were made during the experiments. Table B-2 summarizes the SO₂/SO₃ measurement data, including a comparison of SO₂ measured with this wet method and with the standard probe/permeation drier/DuPont NDUV instrument (Figure B-9 shows the wet SO₂, SO₃ sampling system).

B.2 Solid Samples

Solid samples were taken from the furnace in two ways: isokinetically with a filter-tipped, water-cooled probe, and non-isokinetically with a water-cooled "grab sample" probe and glass cyclone. In the post-flame cavity and convective section the isokinetic sampling system consisted of a probe made at the International Flame Research Foundation, shown schematically in Figure B-10 and a heated Teflon sample line followed by a pump, dry gas meter, pressure gauge, and rotameter for the measurement of the sample flow rate. The grab sample was taken from the furnace with a standard, stainless-steel, water-cooled probe and the solids removed from the sample with a glass cyclone, shown schematically in Figure B-11.

Because the IFRF probe was too large for any of the sample ports in the radiant furnace, a new solids sampling probe was constructed. The probe is shown schematically in Figure B-12 and the sample conditioning/gas flow measurement system is shown in Figure B-13. Sampling for solids in the flame with reactive solids (sorbent) ash and char requires a probe which quenches the sample rapidly (to prevent hot, sticky ash from plugging the probe) without allowing condensation on the probe walls. The sample gas temperature

TABLE B-2. COMPARISON OF THE DUPONT AND
WET SO₂/SO₃ MEASUREMENT

Date	Fuel	Sample #	SO ₂ Dupont	SO ₂ Wet	SO ₃
1/14/83	Nat. Gas/H ₂ S	1	1610	1860	63
1/18/83	Nat. Gas/H ₂ S	1	1097	1072	18
1/18/83	Nat. Gas/H ₂ S	2	404	334	5.3
1/19/83	Nat. Gas/H ₂ S	2	523	556	5.2
1/19/83	Nat. Gas/H ₂ S	3	519	564	0.5
1/19/83	Nat. Gas/H ₂ S	4	486	550	3.3
1/26/83	Nat. Gas/H ₂ S	1	398	364	40.0
1/26/83	Nat. Gas/H ₂ S	2	451	370	0
1/20/83	Indiana 3	1	742	713	5.15
1/20/83	Indiana 3	2	778	511	3.08
1/20/83	Indiana 3	3	855	848	3.1
1/21/83	Indiana 3	1	685	676	.12

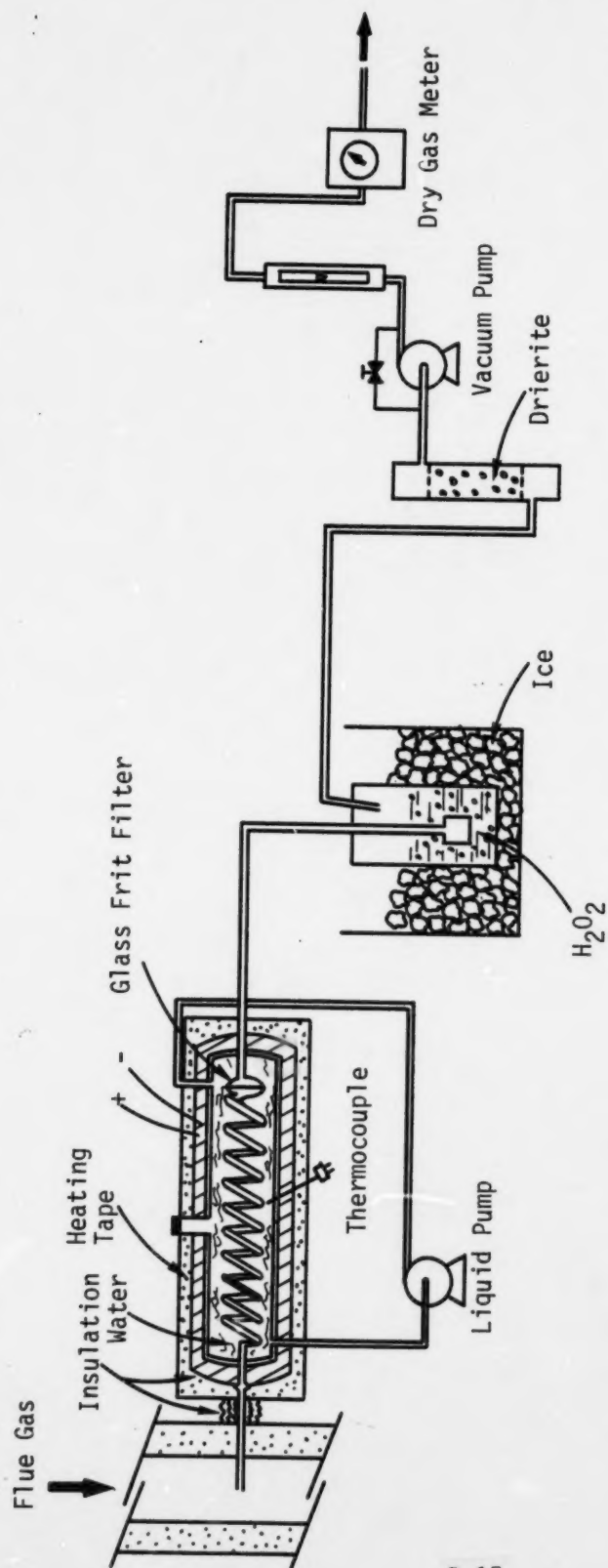


Figure B-9. SO₃, SO₂ Controlled Condensation Wet Measurement System.

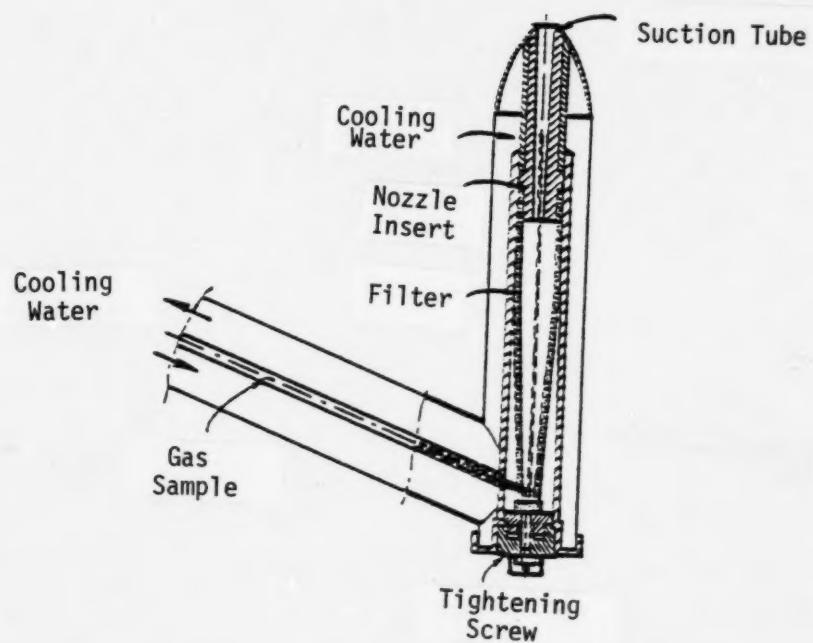


Figure B-10. International Flame Research Foundation solid sampling probe.

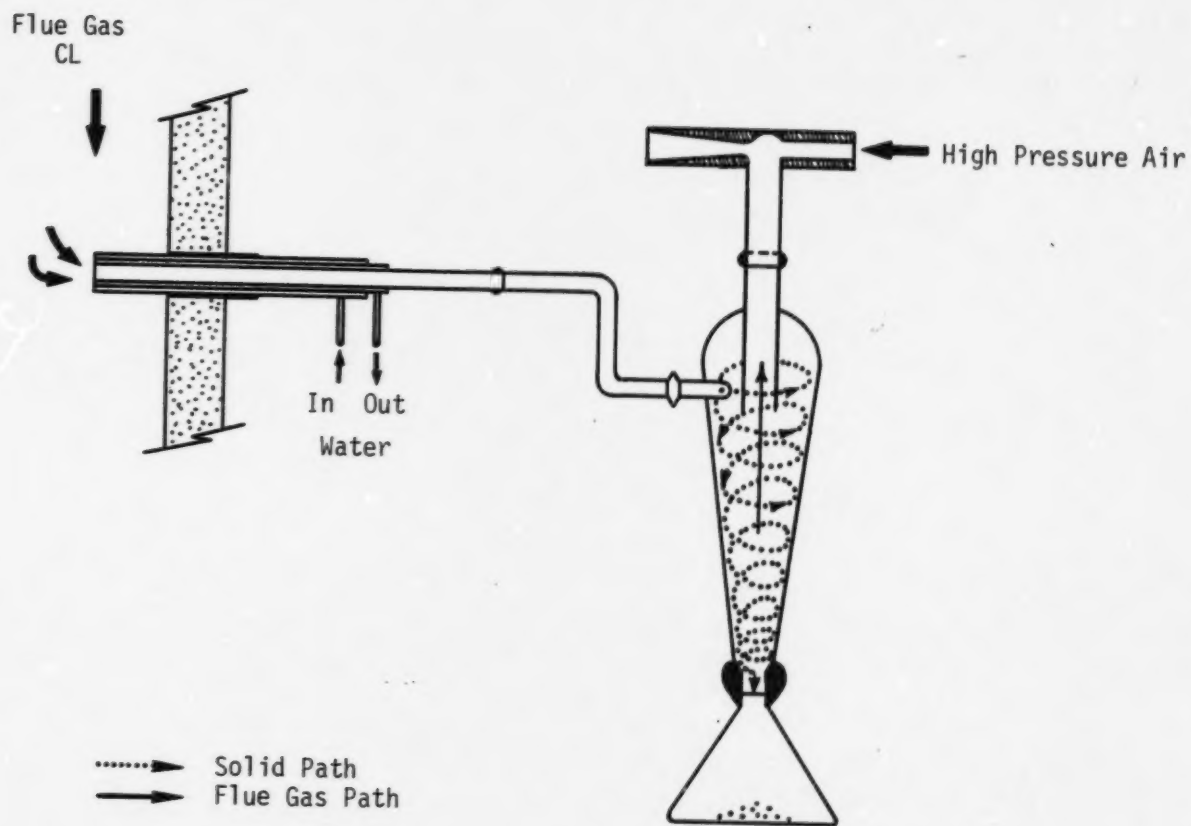


Figure B-11. Grab Sample.

A-F: Sample Temperature
Measurement Locations

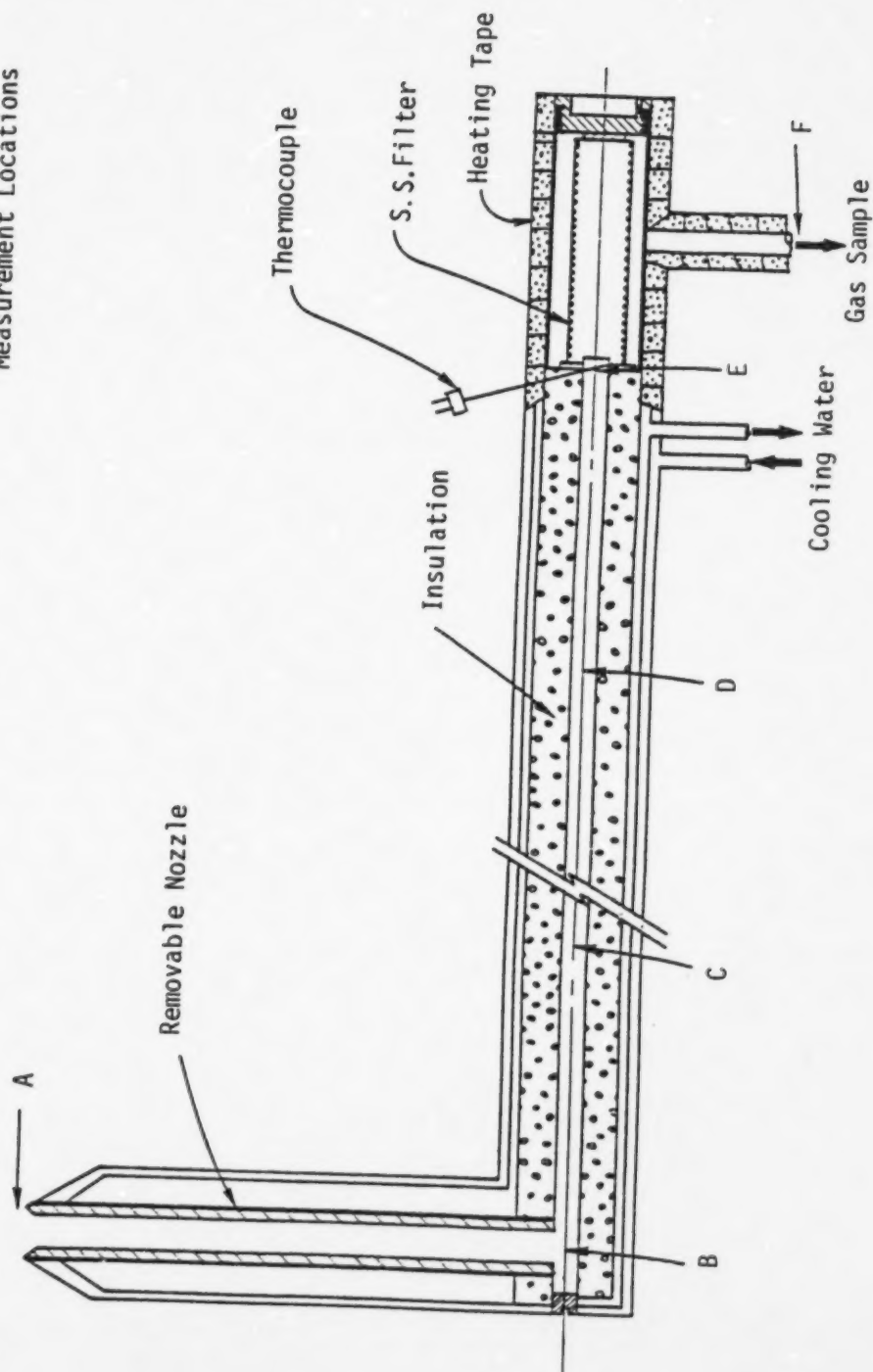
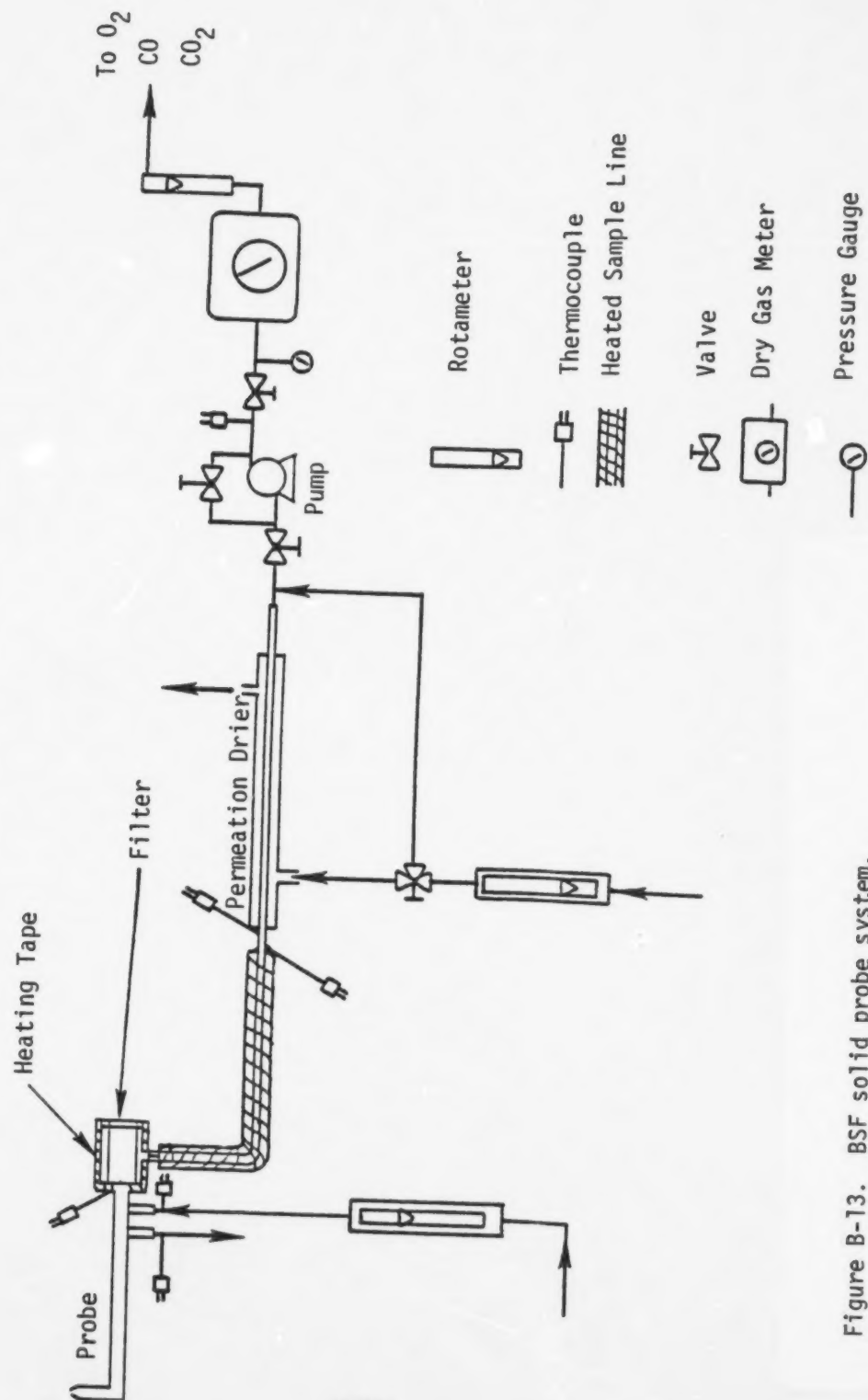


Figure B-12. Solid sampling probe.



B-19

Figure B-13. BSF solid probe system.

profile measured in the solids probe is shown in Figure B-14 for one furnace sampling location. The gas sample flow rate and cooling water-flow rate are adjusted to give sufficient quenching without condensation for different samples locations and furnace conditions (natural gas/coal flame). Solid samples have been taken at the centerline of the radiant furnace at several axial locations from the Indiana coal flame and the natural gas flame.

The solids characteristics which were measured are listed in Table B-1. The measurements are briefly described, with emphasis given to those measurements of special importance to the bench-scale sorbent injection studies. Carbon, hydrogen, nitrogen, ash and oxygen contents of solid samples were measured using a Perkin-Elmer Model 240-B Elemental Analyzer. Sulfur was measured using an instrument manufactured by LECO. The LECO was designed to measure the sulfur content of combustible solids and had to be tested with sorbent and ash samples. The instrument burns the sample at high temperature (2400°F) in an oxygen-enriched atmosphere) and measures by integrating over the combustion time-light absorbed at a specific wavelength in the infrared region, the SO₂ evolved. The instrument is equipped with an analytical balance and a microprocessor system which are used to convert the measured SO₂ content of the gases to equivalent weight percent of sulfur in the sample. Non-combustible solids, including calcium salts and coal ashes, require the use of a combustion accelerator to ensure that all of the sulfur is evolved from the sample. Several combustion accelerators were tested, including V₂O₅, Al₂O₃, and MgO; V₂O₅ was the best for use with sorbent and ash samples.

Several standards were prepared to determine the accuracy of the sulfur measurement methods developed. Calcium sulfate (CaSO₄), pure reagent grade, was mixed in known proportions (by mass) with pure, dry, unreacted calcium carbonate. The sulfur content of these standards was measured and compared to the expected sulfur content. These results are shown in Figure B-15. There was good agreement between the measured and expected values of sulfur. Each point plotted is an average of at least six measurements. Blanks containing pure CaCO₃ or Ca(OH)₂ were run before each measurement.

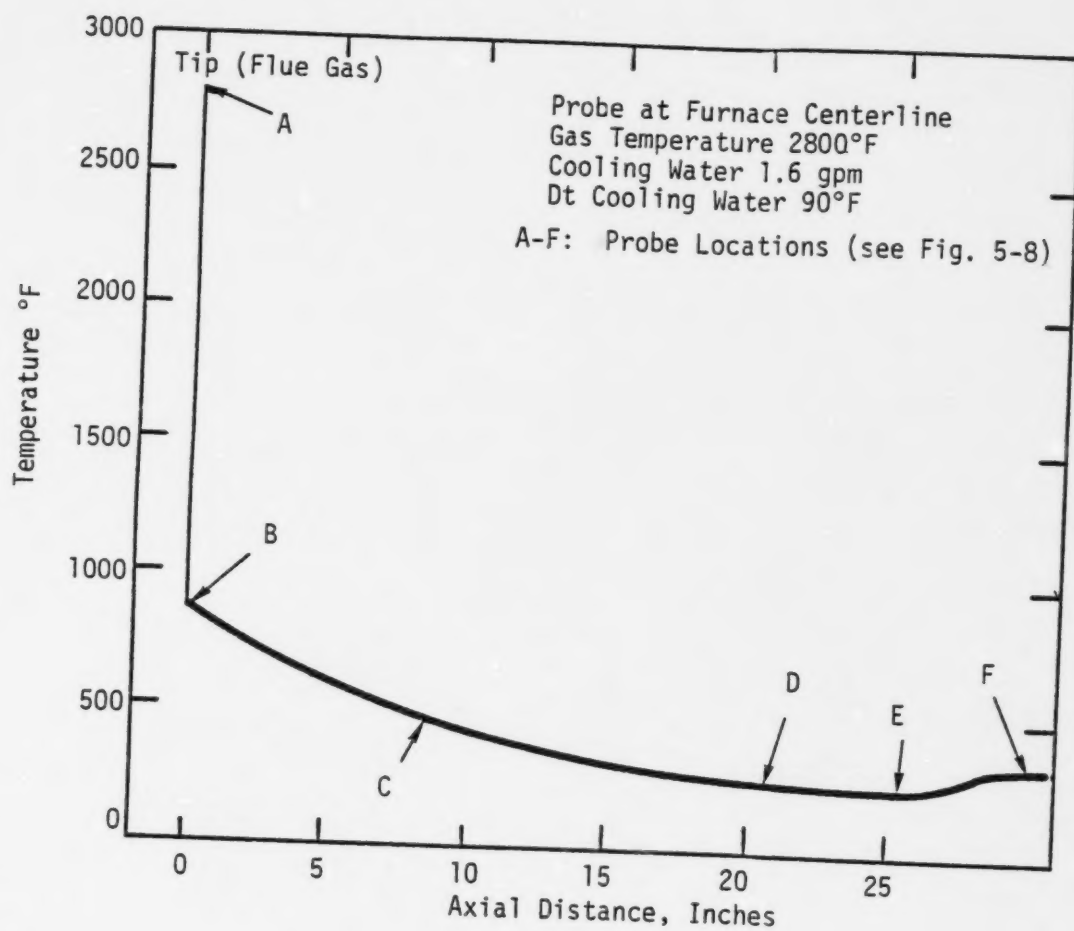


Figure B-14. Solids sampling probe thermal characteristics.

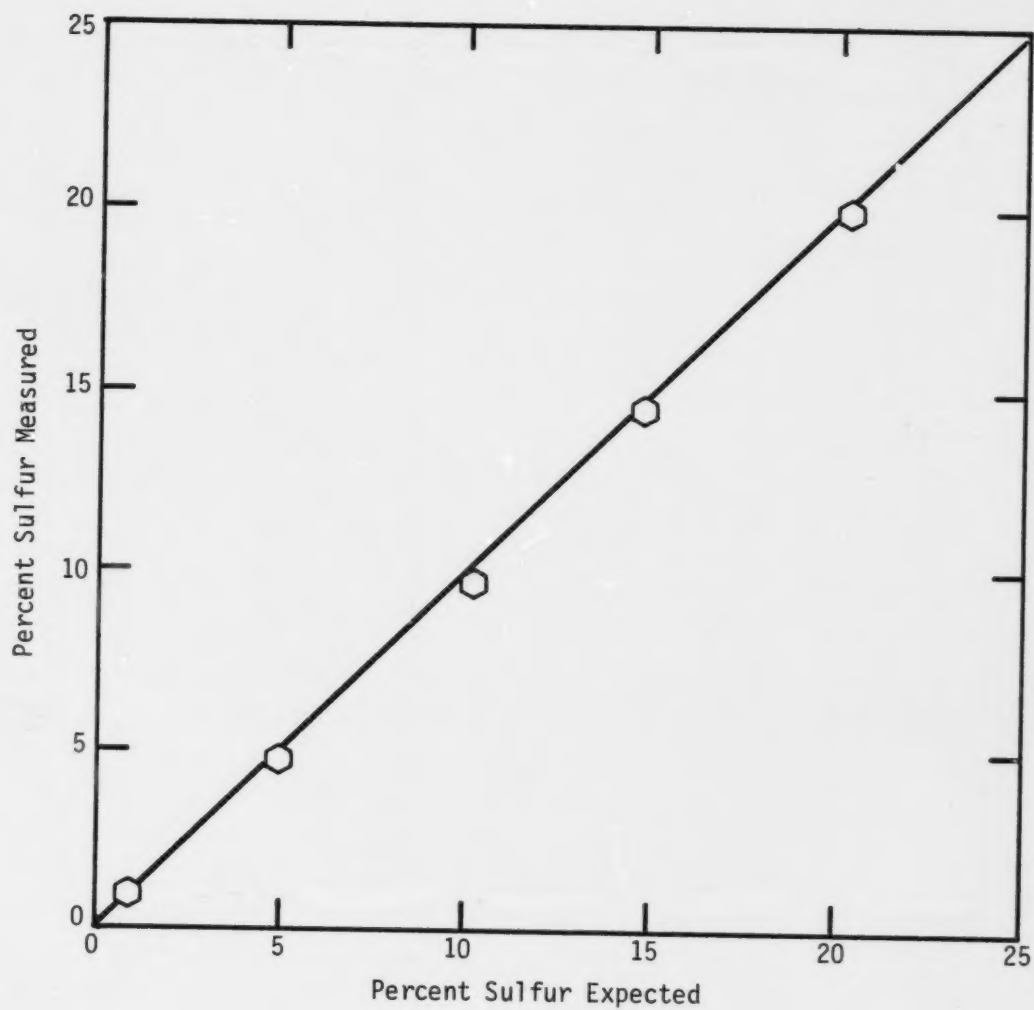


Figure B-15. Calibration curve for known sulfur standards on LECO analyzer.

The surface area of the solid sorbent powders and of ash/sorbent samples from the furnace was determined by gas absorption using an instrument manufactured by Quantichrome, Inc. This instrument is based on the BET method, where surface area is related to the monolayer capacity of an adsorbent. The BET surface areas of porous and non-porous samples are conventionally determined from N_2 adsorption isotherms measured at 77°K. Single or multipoint BET surface area measurements, with either N_2 or CO_2 as the adsorbate, can be made. Sorbent or ash/sorbent sample surface areas were measured using a two-point BET surface area with N_2 as the adsorbate gas. The two-point method was sufficient because the solids behave in a very nearly ideal manner. N_2 was used as the adsorbate because it is easier to use than CO_2 and to eliminate any possibility of a back-reaction between CaO in the ash samples and CO_2 to form $CaCO_3$.

The ability to assess sorbent reactivity is of key importance. Two standard methods of characterizing sorbent reactivity were developed. One method of assessing the degree of dead-burning of a calcine is to determine the rate of dissociation of the calcine in water. A calcine which has been dead-burned will dissociate more slowly than one with an open porous structure, a "soft-burned" stone. A dead-burned stone will be less reactive than a stone which is soft-burned because when a particle dead-burns, the pore structure begins to collapse and less surface area is available for reaction. The rate of dissociation of a sorbent in water is conveniently measured by stirring a known amount of stone in water and titrating the solution with acid to a constant pH (generally to the neutral point, 7.0) at time intervals. The time it takes a stone to dissociate completely (or to add the acid equivalent to the stone) is a simple measure of the sorbent's reactivity. This dissociation test is only useful for unsulfated stones and cannot be used on sorbent/fly ash mixtures because the presence of acidic or basic compounds will interfere with titration of the sorbent to the neutral point. The dissociation characteristics of various calcines are different; however, the dissociation rate of a given stone is affected by dead-burning in a predictable manner.

A second test for the degree of over-burn or dead-burning of a sorbent is the hydration weight gain of the solid. The solid sample is dried at temperature sufficient to remove moisture associated with the solids; water is added, allowed to react with the solids, and evaporated. The weight gain associated with this water uptake can be related to the degree of over-burn of the sorbent. The hydration weight gain test may be used on sulfated samples and on sorbent/ash mixtures. However, the interpretation of the weight gain results requires the characterization of the pure sorbent in terms of dead-burning versus dissociation rate and dead-burning versus hydration weight gain. A characteristic weight gain for a dead-burned or soft-burned sorbent is established and compared to weight gains measured for some of the standard calcines described earlier.

B.3 Temperature Measurement

Furnace wall temperatures were measured using thermocouples embedded in the refractory walls. Temperatures in the radiant and post-flame section were measured using platinum/platinum-rhodium (Type S or Type B) thermocouples. Temperatures in the convective sections were measured using chromel/alumel (Type K) thermocouples.

Gas temperatures were measured using a suction pyrometer. The pyrometer and thermocouples were standard for both gas and coal flames (see Figure B-16). The ceramic shield was chosen to match the fuel. An open ended shield (B-16a) was used in optically-dense ash-laden coal flames in order to limit plugging of the probe tip (and because radiant losses through the open end of the shield are small in the ash-laden gases). A closed-end ceramic shield with holes parallel to the gas flow (B-16b) was used for gas temperature measurements in the natural gas flame.

B.4 Fouling Measurements

Fouling rates were assessed by measuring the skin temperature and heat transfer rates of a simulated convective heat transfer tube. A fouling probe, shown schematically in Figure B-17, and B-18 was set in the post-flame

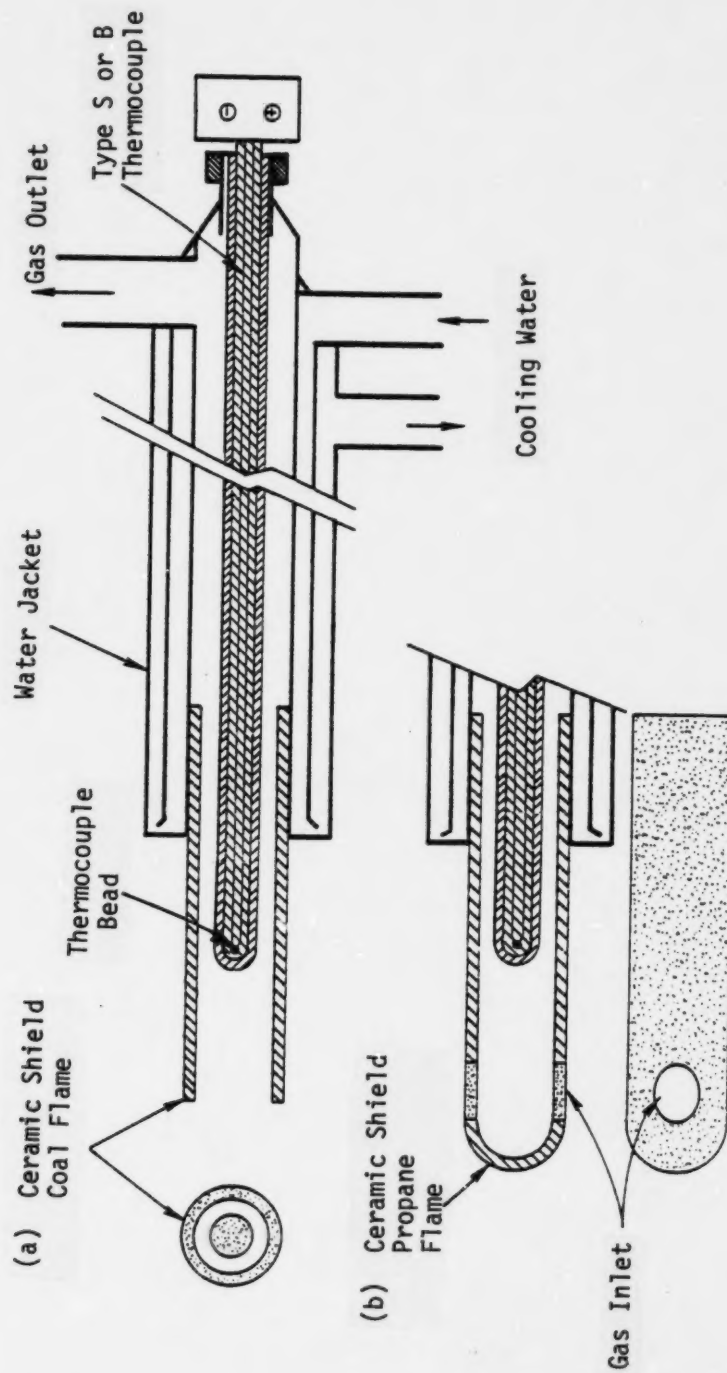


Figure B-16. Suction Pyrometer Schematic.

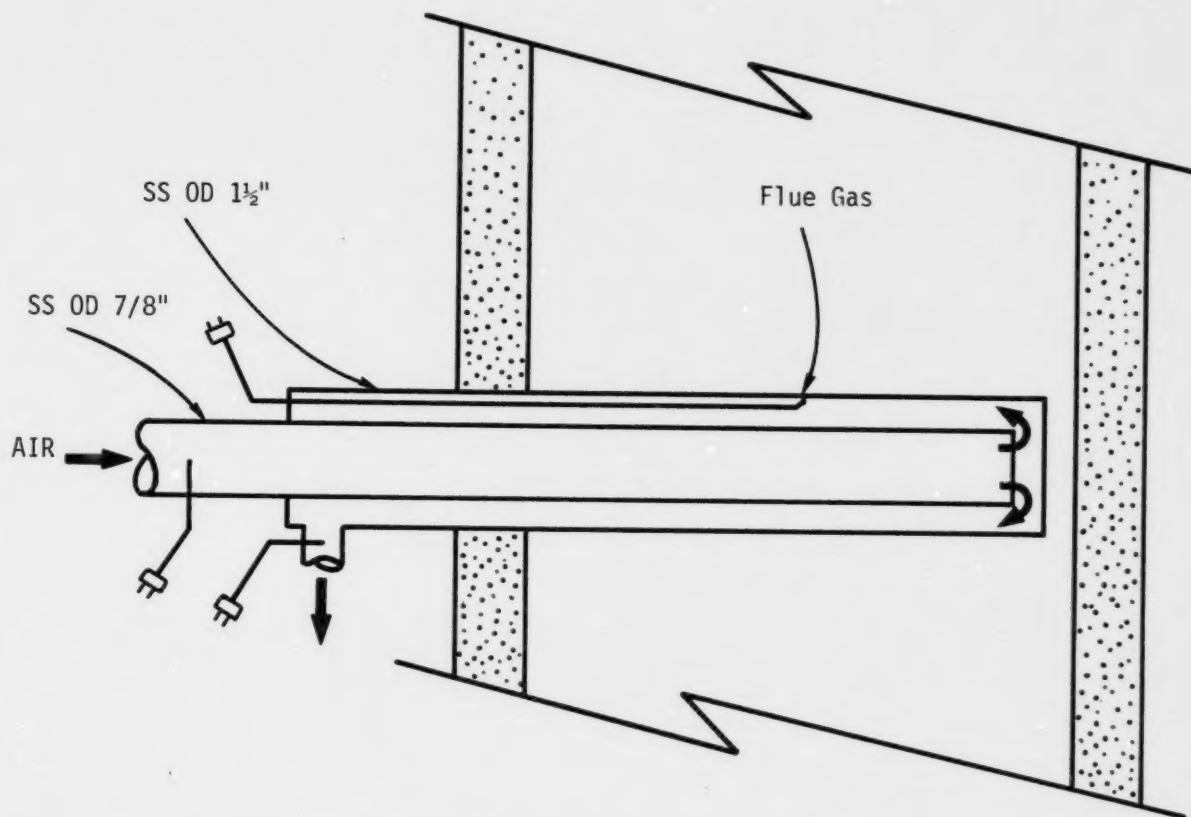


Figure B-17. Fouling Probe.

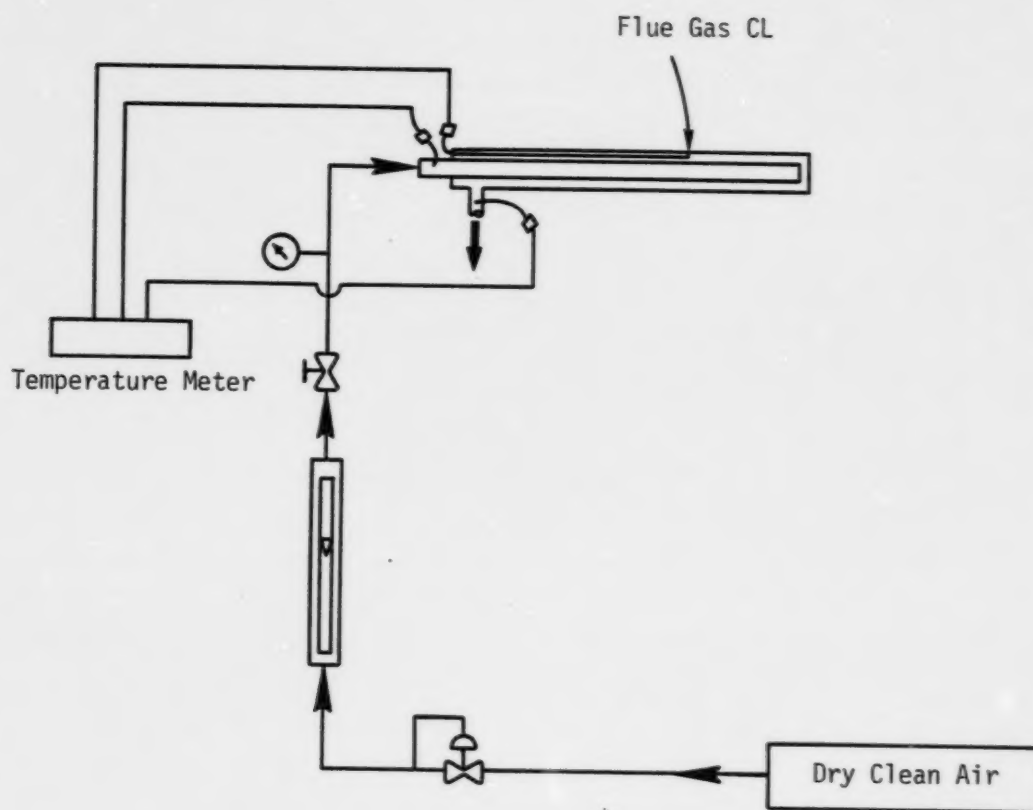


Figure B-18. Fouling Probe System.

section where the gas temperature was approximately 2000°F. The probe skin temperature was monitored and the cooling air temperatures (inlet and outlet) and flow rate were measured. As ash collects on the probe it acts as an insulator and the tube skin temperature drops. The coolant air flow rate was set to give an initial skin temperature at 1500°F and was left constant. The insulating ash layer reduces the probe heat transfer rate (measured by the coolant temperature difference and flow rate); heat removal decreasing as the ash layer builds up.

Fouling tests were from four to eight hours in length. The probe was removed, maintaining the ash layer, at the end of a test run. The deposits were phototgraphed, scraped from the probe and weighed.

B.5 Particle Size Distribution

Particle size distribution measurements were made at the exit of the convective section using modified Brink impactors. The sampling and data reduction methods for these cascade impactors are complex; a complete, detailed description of the method is given in "Procedures Manual for Electrostatic Precipitator Evaluation" (Smith, W. B., et al, EPA-600/7-77-059, 1977).

B.6 Fly Ash Resistivity Measurements

Ash resistivity affects ESP performance and is therefore of interest in the application of limestone injection for pf boilers. Fly ash resistivity measurements can be made in-situ or in a laboratory system. The measurements used for this program were made in-situ using a point-to-plane resistivity probe. Measurements were made at the exit of the convective section before the baghouse. The probe and measurement system is a standard set-up developed by SRI and is described in detail in "Procedures Manual for Electrostatic Precipitator Evaluation" (Smith, W. B., et al, EPA-600/7-77-059, 1977).

APPENDIX C--FUEL AND SORBENT CHARACTERISTICS

Coal Characteristics
 COAL NAME: INDIANA 1073 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	BSF 5-24/1	BSF 5-24/2	BSF 5-25/1	BSF 5-25/2	BSF 5-26/1	BSF 5-26/2
Analyzed by/date:	RKN 6-7-83	RKN 6-7-83	RKN 6-8-83	RKN 6-8-83	RKN 6-8-83	RKN 6-8-83
H ₂ O (ar)	6.82	6.29	5.91	6.16	6.15	6.97
VM (ar)	29.56	30.91	27.58	26.53	25.74	31.14
Ash (ar)	9.64	9.49	9.16	9.79	9.33	9.28
Pyritic S (ar)						
Organic S (ar)						
Sulfate S (ar)						
Total S (ar)	1.06	1.13	1.13	1.14	1.05	1.07
Btu (ar)						
C (daf)	77.52	76.55	76.2	77.08	76.49	76.23
H (daf)	4.98	4.92	4.91	4.97	5.02	5.04
N (daf)	1.56	1.58	1.55	1.57	1.57	1.57
S (dry)	1.14	1.21	1.20	1.22	1.12	1.15
Included MM% (ar)						
SiO ₂ (a)						
Al ₂ O ₃ (a)						
TiO ₂ (a)						
Fe ₂ O ₃ (a)						
CaO (a)						
MgO (a)						
K ₂ O (a)						
Na ₂ O (a)						
SO ₃ (a)						
P ₂ O ₅ (a)						
IDT °F (red)						
AFT °F (red)						
HT °F (red)						
FT °F (red)						
IDT °F (oxid)						
AFT °F (oxid)						
HT °F (oxid)						
FT °F (oxid)						

COAL CHARACTERISTICS

COAL NAME: INDIANA LOT 3 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	BSF 2/2-26-82	N298/11-9-82	BSF 2-25-83/2	BSF 2-25-83/3	BSF 2/1-20-83	BSF 1/2-1-83
Analyzed by/date:	HZ 270/2-26	HZ 12-8-82	RKN 3-10-83	RKN 3-10-83	RKN 2-10-83	RKN 2-10-83
H ₂ O (ar)	3.15	4.37	2.28	3.78	4.0	3.4
VM (ar)	33.19	31.47				
Ash (ar)	10.26	11.92	10.22	10.61	11.58	12.6
Pyritic S (ar)	0.57					
Organic S (ar)	0.44					
Sulfate S (ar)	0.22					
Total S (ar)	1.23	0.86	1.22	1.02	1.04	0.84
Btu (ar)	12355	11814				
C (daf)	81.64	81.30	77.17	77.55	78.85	79.2
H (daf)	5.36	4.84	5.11	4.88	4.17	4.77
N (daf)	1.43	1.86	1.57	1.73	2.0	2.0
S (dry)	1.27	0.90	1.25	1.06	1.08	0.87
Included MM% (ar)						
SiO ₂ (a)	57.51					
Al ₂ O ₃ (a)	23.93					
TiO ₂ (a)	0.94					
Fe ₂ O ₃ (a)	12.19					
CaO (a)	1.26					
MgO (a)	0.61					
K ₂ O (a)	1.18					
Na ₂ O (a)	0.18					
SO ₃ (a)	0.73					
P ₂ O ₅ (a)	0.49					
IDT °F (red)						
AFT °F (red)						
HT °F (red)						
FT °F (red)						
IDT °F (oxid)						
AFT °F (oxid)						
HT °F (oxid)						
FT °F (oxid)						

COAL CHARACTERISTICS

COAL NAME: INDIANA LOT 3 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS				
Sample I.D. #	BSF3/2-17-83	BSF4/1-20-83	BSF5/1-21-83	BSF2-25-83/1	189/823-83
Analyzed by/date:	RKN 3-10-83	RKN 3-10-83	RKN 3-10-83	RKN 3-10-83	HZ DEC 2-83
H ₂ O (ar)	6.94	4.25	3.98	3.14	7.67
VM (ar)					31.27
Ash (ar)	8.53	11.27	9.08	7.59	9.84
Pyritic S (ar)					0.04
Organic S (ar)					0.60
Sulfate S (ar)					0.44
Total S (ar)	1.04	1.34	1.25	1.17	1.08
Btu (ar)					
C (daf)	77.43	77.21	77.11	75.19	79.71
H (daf)	4.94	4.9	4.56	5.00	5.11
N (daf)	1.38	1.3	1.35	1.53	1.5
S (dry)	1.15	1.40	1.31	1.21	1.17
Included MM% (ar)					
SiO ₂ (a)					58.63
Al ₂ O ₃ (a)					23.56
TiO ₂ (a)					0.99
Fe ₂ O ₃ (a)					10.26
CaO (a)					0.95
MgO (a)					0.36
K ₂ O (a)					1.49
Na ₂ O (a)					0.22
SO ₃ (a)					0.43
P ₂ O ₅ (a)					0.47
IDT °F (red)					2360.
AFT °F (red)					2590.
HT °F (red)					2615.
FT °F (red)					>2700.
IDT °F (oxid)					2660.
AFT °F (oxid)					>2700
HT °F (oxid)					
FT °F (oxid)					

COAL CHARACTERISTICS

COAL NAME: INDIANA LOT 3 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	BSF 5-27-83	BSF 6-30/10	BSF 6-30/2	BSF 131	BSF 0183-8-25	BSF 185-3-13
Analyzed by/date:	RKN 6-7-83	RKN 7-14-83	RKN 7-14-83	RKN 8-12-83	RKN 10-2-83	RKN 10-2-83
H ₂ O (ar)	7.13	3.74	3.83	6.52	6.53	4.83
VM (ar)	32.4					
Ash (ar)	9.24	11.76	10.29	9.45	9.25	9.32
Pyritic S (ar)						
Organic S (ar)						
Sulfate S (ar)						
Total S (ar)	1.07	1.28	1.24	1.28	1.16	1.03
Btu (ar)						
C (daf)	76.41	75.28	76.05	75.84	75.82	76.43
H (daf)	4.90	4.98	4.83	4.87	5.0	5.0
N (daf)	1.53	1.49	1.44	1.46	1.59	1.54
S (dry)	1.15	1.33	1.29	1.37	1.24	1.09
Included MM% (ar)						
SiO ₂ (a)						
Al ₂ O ₃ (a)						
TiO ₂ (a)						
Fe ₂ O ₃ (a)						
CaO (a)						
MgO (a)						
K ₂ O (a)						
Na ₂ O (a)						
SO ₃ (a)						
P ₂ O ₅ (a)						
IDT °F (red)						
AFT °F (red)						
HT °F (red)						
FT °F (red)						
IDT °F (oxid)						
AFT °F (oxid)						
HT °F (oxid)						
FT °F (oxid)						

COAL CHARACTERISTICS

COAL NAME: INDIANA Lot 3 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER

BSF FUEL/SORBENT Experiment: INTERACTIONS

Sample I.D. #	BSF1/1-28-83	BSF1/2-11-83	BSF1/2-3-83	BSF5/2-15-83	BSF1/2-17-83	BSF2/2-17-83
Analyzed by/date:	RKN 2-10-83	RKN 3-10-83	RKN 3-10-83	RKN 3-10-83	RKN 3-10-83	RKN 3-10-83
H ₂ O (ar)	4.0	5.3	3.7	3.7	4.89	7.76
VM (ar)						
Ash (ar)	120	10.73	11.9	8.72	7.14	8.91
Pyritic S (ar)						
Organic S (ar)						
Sulfate S (ar)						
Total S (ar)	0.86	0.83	0.847	1.21	1.17	1.08
Btu (ar)						
C (daf)	79.34	76.84	78.32	76.63	75.78	77.47
H (daf)	4.83	4.88	4.73	5.01	4.74	5.04
N (daf)	2.0	1.89	1.95	1.55	1.37	1.36
S (dry)	0.90	0.88	0.88	1.26	1.23	1.18
Included MM% (ar)						
SiO ₂ (a)						
Al ₂ O ₃ (a)						
TiO ₂ (a)						
Fe ₂ O ₃ (a)						
CaO (a)						
MgO (a)						
K ₂ O (a)						
Na ₂ O (a)						
SO ₃ (a)						
P ₂ O ₅ (a)						
IDT °F (red)						
AFT °F (red)						
HT °F (red)						
FT °F (red)						
IDT °F (oxid)						
AFT °F (oxid)						
HT °F (oxid)						
FT °F (oxid)						

COAL CHARACTERISTICS

COAL NAME: INDIANA LOT 3 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #					MEAN	STD. DEV
Analyzed by/date:						
H ₂ O (ar)					5.07	1.54
VM (ar)					29.98	2.54
Ash (ar)					9.96	1.34
Pyritic S (ar)					0.3	0.37
Organic S (ar)					0.41	0.26
Sulfate S (ar)					0.33	0.16
Total S (ar)					1.09	0.14
Btu (ar)					12,085	
C (daf)					77.35	1.65
H (daf)					4.92	0.19
N (daf)					1.57	0.16
S (dry)					1.15	0.15
Included MM% (ar)						
SiO ₂ (a)					58.63	
Al ₂ O ₃ (a)					23.56	
TiO ₂ (a)					0.99	
Fe ₂ O ₃ (a)					10.26	
CaO (a)					0.95	
MgO (a)					0.36	
K ₂ O (a)					1.49	
Na ₂ O (a)					0.22	
SO ₃ (a)					0.43	
P ₂ O ₅ (a)					0.47	
IDT °F (red)					2360	
AFT °F (red)					2590	
HT °F (red)					2615	
FT °F (red)					>2700	
IDT °F (oxid)					2600	
AFT °F (oxid)					>2700	
HT °F (oxid)						
FT °F (oxid)						

COAL CHARACTERISTICS

COAL NAME: SARR COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	326/5-19-83	101855/7-11-83	BSF 7-11-83	BSF 8-12-83	0121 7-25-83	SWS #7/8-10
Analyzed by/date:	HZ 8-11-83	HZ 10-14-83	RKN 9-19-83	RKN 18-12-83	RKN 10-2-83	RKN 10-12-83
H ₂ O (ar)	2.80		1.78	2.1	1.92	1.41
VM (ar)	31.37					
Ash (ar)	8.02		7.10	7.23	6.8	7.1
Pyritic S (ar)	0.37					
Organic S (ar)	0.46					
Sulfate S (ar)	0.02					
Total S (ar)	0.85		0.72	0.72	0.784	0.79
Btu (ar)	13107.					
C (daf)	83.33		80.38	80.83	79.64	80.25
H (daf)	5.25		5.13	5.18	5.16	5.09
N (daf)	1.16		1.34	1.37	1.35	1.34
S (dry)	0.87		0.74	0.74	0.80	0.80
Included MM% (ar)						
SiO ₂ (a)	43.59	44.59				
Al ₂ O ₃ (a)	24.86	25.13				
TiO ₂ (a)	0.88	0.66				
Fe ₂ O ₃ (a)	10.97	10.01				
CaO (a)	4.85	4.56				
MgO (a)	3.19	2.94				
K ₂ O (a)	3.27	3.28				
Na ₂ O (a)	0.47	0.50				
SO ₃ (a)	5.38	5.85				
P ₂ O ₅ (a)	0.18	0.17				
IDT °F (red)	2250.	2220.				
AFT °F (red)	2385.	2335.				
HT °F (red)	2420.	2480.				
FT °F (red)	2600.	2510.				
IDT °F (oxid)	2325.	2310.				
AFT °F (oxid)	2390.	2420.				
HT °F (oxid)	2460.	2520.				
FT °F (oxid)	2610.	2590				

COAL CHARACTERISTICS

COAL NAME: SARR COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #					MEAN	STD. DEV
Analyzed by/date:						
H ₂ O (ar)					2.00	0.513
VM (ar)					31.37	
Ash (ar)					7.25	0.458
Pyritic S (ar)					0.37	
Organic S (ar)					0.46	
Sulfate S (ar)					0.02	
Total S (ar)					0.773	0.054
Btu (ar)					13107.	
C (daf)					80.88	1.43
H (daf)					5.16	0.606
N (daf)					1.312	0.085
S (dry)					0.79	0.053
Included MM% (ar)						
SiO ₂ (a)					44.99	0.707
Al ₂ O ₃ (a)					25.0	0.19
TiO ₂ (a)					0.77	0.16
Fe ₂ O ₃ (a)					10.49	0.678
CaO (a)					4.7	0.205
MgO (a)					3.06	0.176
K ₂ O (a)					3.27	0.007
Na ₂ O (a)					0.485	0.0212
SO ₃ (a)					5.615	0.332
P ₂ O ₅ (a)					0.175	0.007
IDT °F (red)					2235.	21.21
AFT °F (red)					2360.	35.35
HT °F (red)					2450.	42.42
FT °F (red)					2555.	63.63
IDT °F (oxid)					2317.5	10.60
AFT °F (oxid)					2405.	21.21
HT °F (oxid)					2490.	42.42
FT °F (oxid)					2600.	14.14

COAL CHARACTERISTICS

COAL NAME: ILLINOIS #6 LOT 1 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER B S F FUEL / SORBENT Experiment: INTERACTIONS

Sample I.D. #	MD 4-18-83	303/4-15-83	BSF 4-15-83	BSF 4-18-83	BSF 5-31-83	0177/8-17-83
Analyzed by/date:	HZ 5-17-83	HZ 5-5-83	RKN 4-20-83	RKN 4-20-83	RKN 6-7-83	RKN 10-2-83
H ₂ O (ar)	7.69	7.79	4.70	5.64	6.47	5.37
VM (ar)		33.89	41.93	47.83	30.7	
Ash (ar)	7.10	10.42	9.62	10.82	10.39	10.37
Pyritic S (ar)		0.19				
Organic S (ar)		2.15				
Sulfate S (ar)		0.77				
Total S (ar)	3.46	3.11	3.33	3.68	3.26	3.59
Btu (ar)	10599.	10537	12017			
C (daf)	70.63	73.87	69.23	69.72	70.18	73.52
H (daf)	4.73	5.	4.92	4.81	5.00	5.31
N (daf)	1.28	1.27	1.47	1.38	1.37	1.40
S (dry)	3.75	3.37	3.50	3.90	3.50	3.79
Included MM% (ar)						
SiO ₂ (a)	53.13	54.10				
Al ₂ O ₃ (a)	17.59	18.23				
TiO ₂ (a)	0.49	0.65				
Fe ₂ O ₃ (a)	15.47	14.26				
CaO (a)	4.18	5.31				
MgO (a)	2.13	0.55				
K ₂ O (a)	2.17	2.04				
Na ₂ O (a)	0.95	1.23				
SO ₃ (a)	4.80	4.81				
P ₂ O ₅ (a)	0.33	0.29				
IDT °F (red)		2060.				
AFT °F (red)		2090.				
HT °F (red)		2290.				
FT °F (red)		2430.				
IDT °F (oxid)		2240.				
AFT °F (oxid)		2300.				
HT °F (oxid)		2440.				
FT °F (oxid)		2580.				

COAL CHARACTERISTICS

COAL NAME: ILLINOIS #6 Lot 1 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	0183/8-22-83	183/81/8-22			MEAN	STD DEV
Analyzed by/date:	RKN 10-2-83	HZ DEC 2, 82				
H ₂ O (ar)	5.25	6.64			6.19	1.23
VM (ar)		36.74			38.22	6.77
Ash (ar)	8.44	9.06			9.52	1.27
Pyritic S (ar)		0.80			0.50	0.43
Organic S (ar)		2.38			2.27	0.16
Sulfate S (ar)		0.39			0.58	0.27
Total S (ar)	3.57	3.57			3.44	0.19
Btu (ar)		11678			11208.	752.
C (daf)	73.24	77.04			72.17	2.68
H (daf)	5.30	5.31			5.04	0.23
N (daf)	1.42	1.38			1.37	0.07
S (dry)	3.77	3.82			3.70	0.19
Included MM% (ar)						
SiO ₂ (a)		50.52			52.58	1.83
Al ₂ O ₃ (a)		17.04			17.62	0.60
TiO ₂ (a)		0.64			0.59	0.09
Fe ₂ O ₃ (a)		17.77			15.83	1.78
CaO (a)		3.72			4.40	0.82
MgO (a)		0.99			1.22	0.815
K ₂ O (a)		2.44			2.21	0.2
Na ₂ O (a)		1.36			1.18	0.21
SO ₃ (a)		3.93			4.51	0.5
P ₂ O ₅ (a)		0.21			0.28	0.06
IDT °F (red)		2010.			2035.	35.35
AFT °F (red)		2050.			2070.	28.28
HT °F (red)		2195.			2242.	67.17
FT °F (red)		2335.			2382.5	67.17
IDT °F (oxid)		2260.			2250.	14.14
AFT °F (oxid)		2380.			2340.	56.56
HT °F (oxid)		2480			2460.	28.28
FT °F (oxid)		2500.			2540.	56.56

COAL CHARACTERISTICS

COAL NAME: UTAH COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER B S F FUEL / SORBENT Experiment: INTERACTIONS

Sample I.D. # BSF5-20-83 BSF5-23/1 BSF5-23/2 BSF7-20-83 BSF8-12-83 0161/8-12-83
 Analyzed by/date: RKN6-8-83 RKN6-8-83 RKN6-8-83 RKN8-12-83 RKN8-15-83 RKN10-12-83

H ₂ O (ar)	4.64	4.88	5.71	2.97	2.97	1.06
VM (ar)	38.61	38.26	37.75			
Ash (ar)	6.42	6.92	6.81	7.66	7.28	9.24

Pyritic S (ar)						
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Organic S (ar)						
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Sulfate S (ar)						
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Total S (ar)	0.86	0.84	0.86	0.87	0.87	0.79
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Btu (ar)						
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C (daf)	74.75	75.48	75.00	76.0	74.27	76.14
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H (daf)	5.39	5.44	5.32	5.4	5.54	5.70
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N (daf)	1.55	1.56	1.56	1.51	1.59	1.60
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S (dry)	0.90	0.88	0.91	0.90	0.90	0.80
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Included MM% (ar)						
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SiO ₂ (a)						
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Al ₂ O ₃ (a)						
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TiO ₂ (a)						
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Fe ₂ O ₃ (a)						
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CaO (a)						
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MgO (a)						
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K ₂ O (a)						
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Na ₂ O (a)						
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SO ₃ (a)						
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P ₂ O ₅ (a)						
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IDT °F (red)						
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AFT °F (red)						
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HT °F (red)						
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FT °F (red)						
-------------	--	--	--	--	--	--

IDT °F (oxid)						
---------------	--	--	--	--	--	--

AFT °F (oxid)						
---------------	--	--	--	--	--	--

HT °F (oxid)						
--------------	--	--	--	--	--	--

FT °F (oxid)						
--------------	--	--	--	--	--	--

COAL CHARACTERISTICS

COAL NAME: UTAH COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	BSF4-15-83	308/4-15-83	327/5-31-83		MEAN	STD. DEV
Analyzed by/date:	RKN4-20-83	HZ 5-5-83	HZ 8-11-83			
H ₂ O (ar)	3.20	5.21	4.44		3.90	1.461
VM (ar)	42.78	39.14	38.1		40.0	2.457
Ash (ar)	7.26	8.00	9.05		7.62	0.977
Pyritic S (ar)		0.10	0.17		0.135	0.05
Organic S (ar)		0.57	0.57		0.57	0.0
Sulfate S (ar)		0.05	0.18		0.115	0.092
Total S (ar)	0.88	0.72	0.92		0.846	0.0583
Btu (ar)	12699	11986.	12045.		12243.	395.7
C (daf)	74.27	78.26	79.12		75.92	1.72
H (daf)	5.535	5.62	5.58		5.502	0.123
N (daf)	1.6	1.48	1.33		1.53	0.0855
S (dry)	0.91	0.76	0.96		0.88	0.0614
Included MM% (ar)						
SiO ₂ (a)		64.42	63.70		64.06	0.509
Al ₂ O ₃ (a)		17.82	19.95		18.89	1.506
TiO ₂ (a)		0.78	0.78		0.78	0.0
Fe ₂ O ₃ (a)		3.79	5.77		4.78	1.4
CaO (a)		5.72	4.69		5.205	1.0
MgO (a)		0.22	1.20		0.71	0.693
K ₂ O (a)		0.93	1.39		1.16	0.325
Na ₂ O (a)		0.77	0.77		0.77	0.0
SO ₃ (a)		4.84	5.05		4.945	1.0
P ₂ O ₅ (a)		0.45	0.40		0.425	0.035
IDT °F (red)		2290.	2185.		2238.	74.24
AFT °F (red)		2380.	2380.		2380.	0.0
HT °F (red)		2520.	2445.		2483.	53.03
FT °F (red)		> 2700.	> 2700.		2700.	0.0
IDT °F (oxid)		2320.	2320.		2320.	0.0
AFT °F (oxid)		2470.	2405.		2438.	45.96
HT °F (oxid)		2580.	2465.		2523.	81.32
FT °F (oxid)		> 2700.	> 2700.		2700.	0.0

COAL CHARACTERISTICS

COAL NAME: INDIANA LOT5 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	0169 / 8-15-83	0172 / 8-15-83	162 / 84/8-13		MEAN	STD DEV
Analyzed by/date:	RKN 10-2-83	RKN 10-2-83	HZ DEC 2, 83			
H ₂ O (ar)	2.65	3.48	4.27		3.47	0.81
VM (ar)			33.44		33.44	0.0
Ash (ar)	8.30	8.24	9.07		8.53	0.46
Pyritic S (ar)			1.06		1.06	0.
Organic S (ar)			0.54		0.54	0.
Sulfate S (ar)			0.62		0.62	0.
Total S (ar)	2.40	2.21	2.22		2.28	0.10
Btu (ar)			12151.		12151.	0.
C (daf)	75.43	75.9	79.18		76.83	2.04
H (daf)	5.16	5.19	5.36		5.23	0.107
N (daf)	1.56	1.54	1.51		1.54	0.025
S (dry)	2.47	2.29	2.32		2.36	0.096
Included MM% (ar)						
SiO ₂ (a)			45.31		45.31	
Al ₂ O ₃ (a)			24.62		24.62	
TiO ₂ (a)			0.68		0.68	
Fe ₂ O ₃ (a)			23.70		23.70	
CaO (a)			0.84		0.84	
MgO (a)			0.32		0.32	
K ₂ O (a)			1.25		1.25	
Na ₂ O (a)			0.24		0.24	
SO ₃ (a)			0.88		0.88	
P ₂ O ₅ (a)			0.21		0.21	
IDT °F (red)			2190.		2190.	
AFT °F (red)			2470.		2470.	
HT °F (red)			2650.		2650.	
FT °F (red)			2690.		2690.	
IDT °F (oxid)			2520.		2520.	
AFT °F (oxid)			2620.		2620.	
HT °F (oxid)			2660.		2660.	
FT °F (oxid)			>2700.		>2700.	

COAL CHARACTERISTICS

COAL NAME: INDIANA LOT 4 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	BSF 6-2-83			102102/9-7-83	325/5-24-83	1866/6-3-83
Analyzed by/date:	RKN 6-7-83			HZ 9-23-83	HZ 8-11-83	HZ DEC 2, 83
H ₂ O (ar)	2.65			9.17	5.98	5.74
VM (ar)	32.5			28.40	29.83	32.78
Ash (ar)	6.81			11.88	9.48	8.40
Pyritic S (ar)					0.35	0.29
Organic S (ar)					0.21	0.66
Sulfate S (ar)					0.71	0.35
Total S (ar)	1.29			1.33	1.27	1.30
Btu (ar)				10688.	11847.	12102.
C (daf)	78.33			78.93	80.96	80.70
H (daf)	5.31			4.75	5.08	5.25
N (daf)	1.60			1.47	1.41	1.57
S (dry)	1.33			1.46	1.35	1.38
Included MM% (ar)						
SiO ₂ (a)					57.60	57.61
Al ₂ O ₃ (a)					25.21	22.42
TiO ₂ (a)					0.93	0.88
Fe ₂ O ₃ (a)					9.82	10.59
CaO (a)					1.28	1.45
MgO (a)					0.75	0.72
K ₂ O (a)					2.45	2.35
Na ₂ O (a)					0.38	0.52
SO ₃ (a)					0.84	0.77
P ₂ O ₅ (a)					0.27	0.32
IDT °F (red)				2400.	2440.	2380.
AFT °F (red)				2460.	2675.	2495.
HT °F (red)				2590.	>2700.	2600.
FT °F (red)				2640.	>2700.	>2700.
IDT °F (oxid)				2465.	2590.	2520.
AFT °F (oxid)				2650.	2700.	2680.
HT °F (oxid)				>2700.	>2700.	>2700.
FT °F (oxid)				>2700.	>2700.	

COAL CHARACTERISTICS

COAL NAME: INDIANA LOT 4 COUNTY: _____ SEAM: _____
 PROVIDENCE: _____ REGION: _____ STATE: _____
 GROUP: _____ FORMATION: _____ FIELD: _____
 RANK: _____ VIT., EXIN. (daf) _____ AGE: _____

Used at: EER	BSF FUEL/SORBENT Experiment: INTERACTIONS					
Sample I.D. #	1388/6-6-83	1389/6-16-83			MEAN	STD. DEV
Analyzed by/date:	RKN II-1-83	RKN II-1-83				
H ₂ O (ar)	4.10	3.96			5.26	2.27
VM (ar)	37.23	36.89			32.93	3.59
Ash (ar)	8.19	8.12			8.81	1.72
Pyritic S (ar)					0.32	0.04
Organic S (ar)					0.43	0.32
Sulfate S (ar)					0.53	0.25
Total S (ar)	1.129	1.31			1.30	0.02
Btu (ar)					11547.	753.6
C (daf)	77.09	77.93			79.0	1.54
H (daf)	5.08	5.11			5.16	0.19
N (daf)	1.61	1.58			1.54	0.08
S (dry)	1.35	1.37			1.37	0.045
Included MM% (ar)						0.
SiO ₂ (a)					57.6	1.97
Al ₂ O ₃ (a)					23.82	0.035
TiO ₂ (a)					.91	0.54
Fe ₂ O ₃ (a)					16.28	.54
CaO (a)					1.37	0.12
MgO (a)					0.73	0.02
K ₂ O (a)					2.4	0.07
Na ₂ O (a)					0.45	0.099
SO ₃ (a)					0.805	0.05
P ₂ O ₅ (a)					0.296	0.035
IDT °F (red)					2406.	30.55
AFT °F (red)					2543.	115.4
HT °F (red)					2630.	60.82
FT °F (red)					>2700.	
IDT °F (oxid)					2525.	62.64
AFT °F (oxid)					2677.	25.16
HT °F (oxid)					>2700.	
FT °F (oxid)					>2700.	

TABLE C-1. SORBENT CHARACTERISTICS

SORBENT	Fredonia Fine 	MW 125 	Vicron 200 	Ca(OH) ₂ RWE	CaCO ₃ RWE
Petrographic Charact.					
Type	Calcite	Calcite	Calcite		
Composition	CaCO ₃	CaCO ₃	CaCO ₃	Ca(OH) ₂	CaCO ₃
Grain Size μm	fine	500-700	500-700	-	-
Top Size μm	~ 50	> 100	~ 100	40	> 100
Mean Size μm	4	30	17	3.5	17
Bottom Size μm	.3	.7	$\sim .4$	0.5	0.5
Density gm/cc	2.76	2.76	2.76	2.35	2.76
Oil Absorption					
Surface Area	2.34	0.42	0.8	12.1	0.88
Ignition Wt. Loss 500°C					
1000°C	42.8	41.2	43.7	25.3	42.2
SA (1000°C) m ² /gm	1.56	3.58	4.27	1.64	1.48
Hydration Wt. Gain (1000°C)					
Acid Titration					
Chemical Comp. (%)					
Ca					
Al					
Si					
Fe					
Na					
Mg					
K					
Cr					
P					
Cl					
S					

TABLE C-1. SORBENT CHARACTERISTICS (cont.)

SORBENT	Vicron 45-3 ○	Vicron 15-15 ◇	Colton Lime ◇	Mich. Marl □	Mich. Marl <200 Mesh ■
Petrographic Character Type	Calcite	Calcite	Hydrated Lime	Marl	Marl
Composition	CaCO ₃	CaCO ₃	Ca(OH) ₂	CaCO ₃	CaCO ₃
Grain Size μ m	500-700	500-700	N.A.	Very Fine	Very Fine
Top Size μ m	45, 40	15	80	>100	60
Mean Size μ m	11, 12	3	12.5	18.0	11.0
Bottom Size μ m	.3, .8	.15	.7, 4	1.0	1.0
Density gm/cm ³	2.757	2.757	2.353	2.533	2.533
Oil Absorption	14	21			
Surface Area	0.9, .6	2.73	10.4, 13.8		2.27
Ignition Wt. Loss % 500°C	44.0, 41.0	44.0	26.4, 26.0	42.0	42.0
1000°C					
SA (1000°C) m ² /gm	6.7, 3.7		1.86		
Hydration wt. gain (1000°C)	33.08	34.26	33.25	31.56	
Acid Titration					
Chemical Comp. (%)					
Ca	39.2	39.3	48.9	25.0	30.1
Al	0.07	0.08	0.28	1.09	0.67
Si	0.07	0.07	1.08	9.29	3.63
Fe	0.037	0.071	0.164	0.873	0.262
Na	0.022	0.017	0.034	0.188	0.119
Mg	0.485	0.422	0.255	0.931	1.02
K	0.011	0.010	0.129	0.444	0.238
Cr	0.006	0.009	0.005	0.21	0.005
Cl					
S					

TABLE C-1. SORBENT CHARACTERISTICS (cont.)

SORBENT	Dolomite D	SM Carbonate O	Fredonia C Δ	SM Ca(OH) ₂ △	74 micron -5% K ₂ CO ₃ ●
Petrographic Charact.					
Type	Dolomite		Calcite		
Composition	CaCO ₃ MgCO ₃	CaCO ₃	CaCO ₃	Ca(OH) ₂	CaCO ₃ /K ₂ CO ₃
Grain Size μm			fine		
Top Size μm	<100	>100	>100	30	
Mean Size μm	34.0, 40.	16	10	3.5	
Bottom Size μm	1.0	1.5	0.4	0.3	
Density gm/cc	2.855	2.76	2.76	2.35	
Oil Absorption					
Surface Area	.64, .60	3.42	5.06	13.5, 12.1	
Ignition Wt. Loss 500°C					
1000°C	47.1, 44.2		43.3	25.3	
SA (1000°C) m ² /gm	9.17		1.34	1.64	
Hydration Wt. Gain (1000°C)	67.5		31.6		
Acid Titration					
Chemical Comp. (%)					
Ca	21.0	38.9	40.0	51.0	
Al	0.09	0.09		0.26	
Si	0.37	0.76		0.80	
Fe	0.102	.09		0.22	
Na	0.033				
Mg	12.1	0.35	.74		
K	0.039			0.51	
Cr	0.27				
P					
Cl					
S					

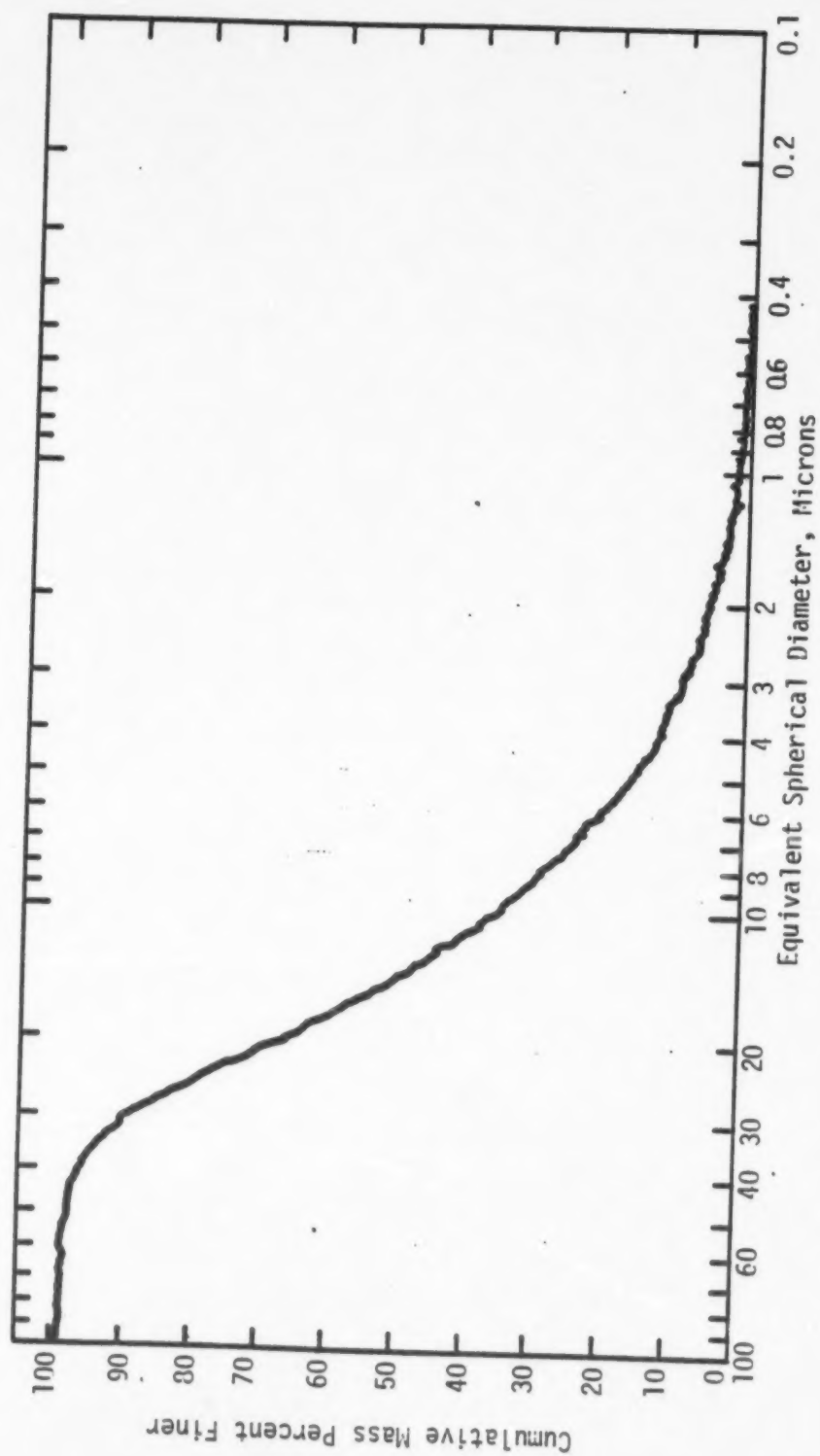


Figure C-1. Particle size distribution for Marble White 325, EER/BSF.

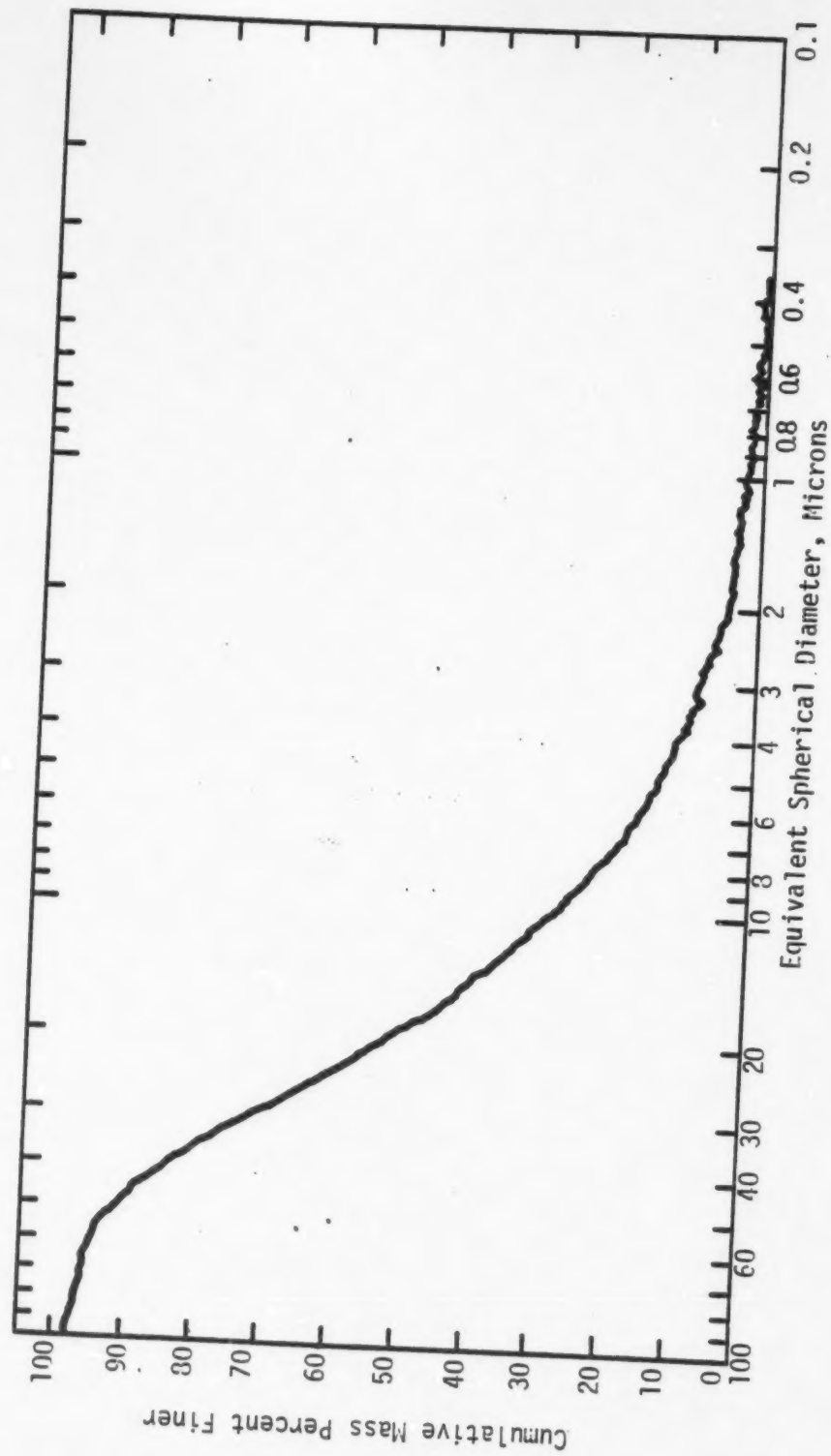


Figure C-2. Particle size distribution for Vicron 200, EER/BSF.

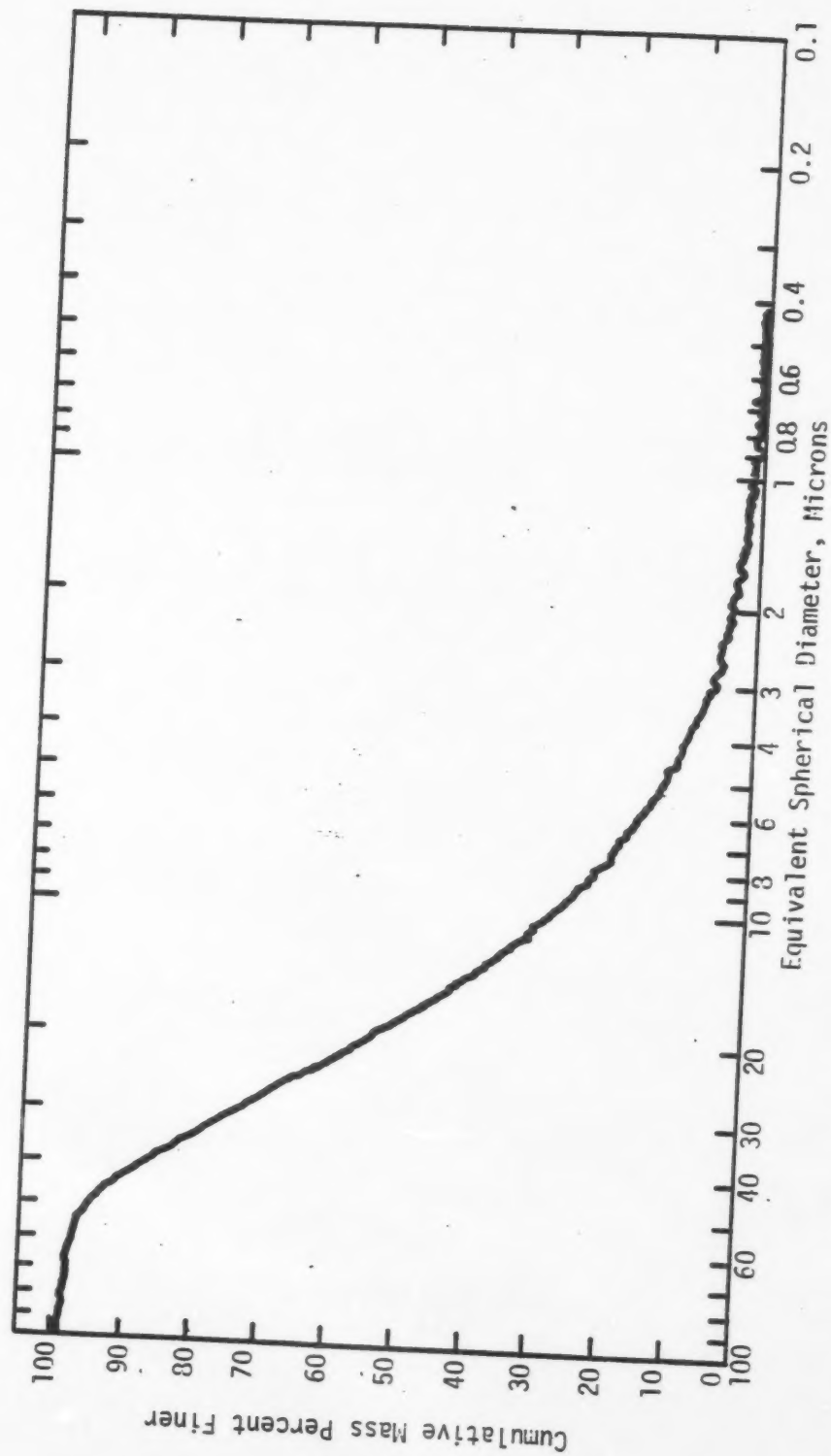


Figure C-3. Particle size distribution for Marble White 200, EER/BSF.

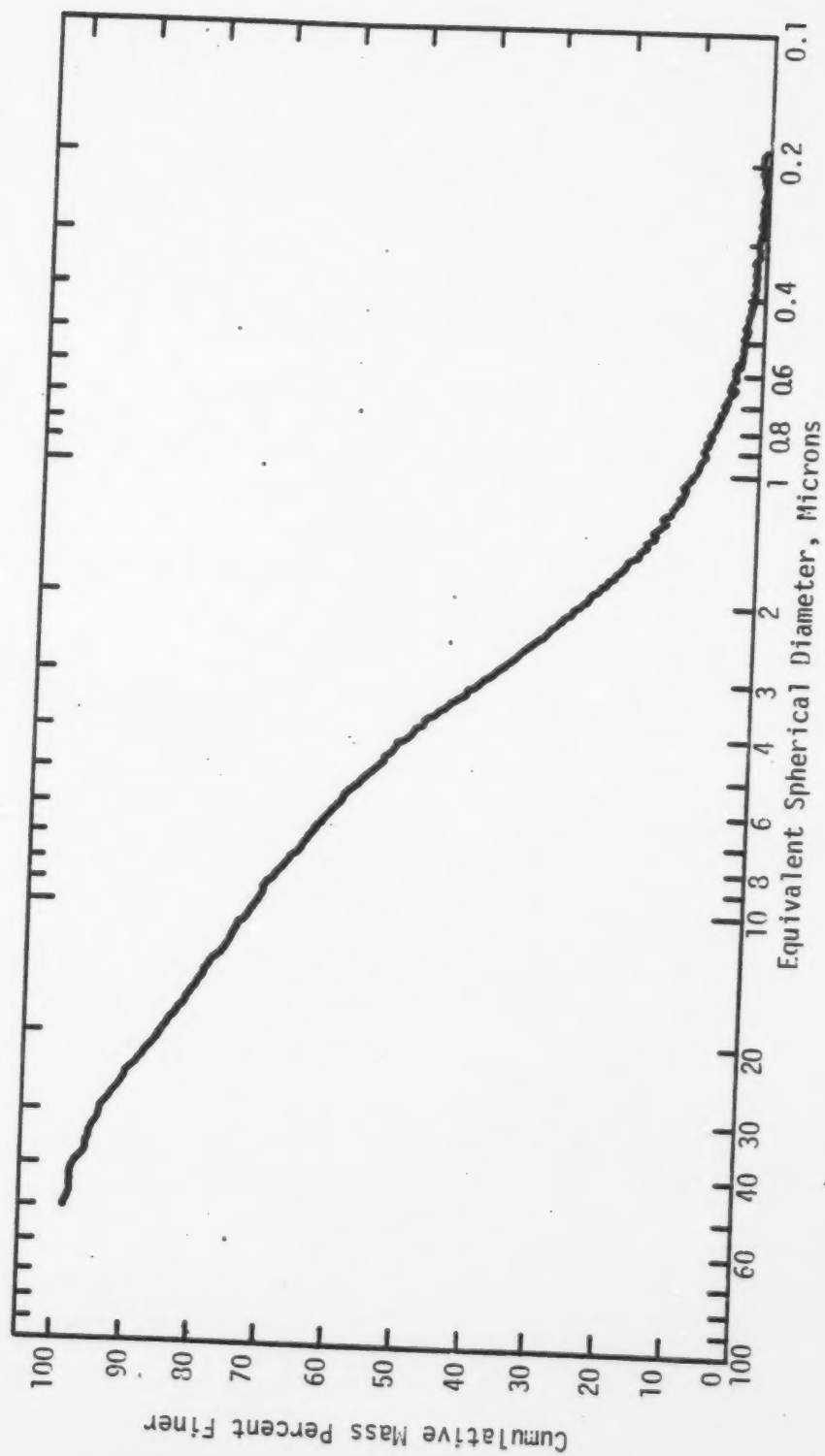


Figure C-4. Particle size distribution for Fredonia (fine), EER/BSF.

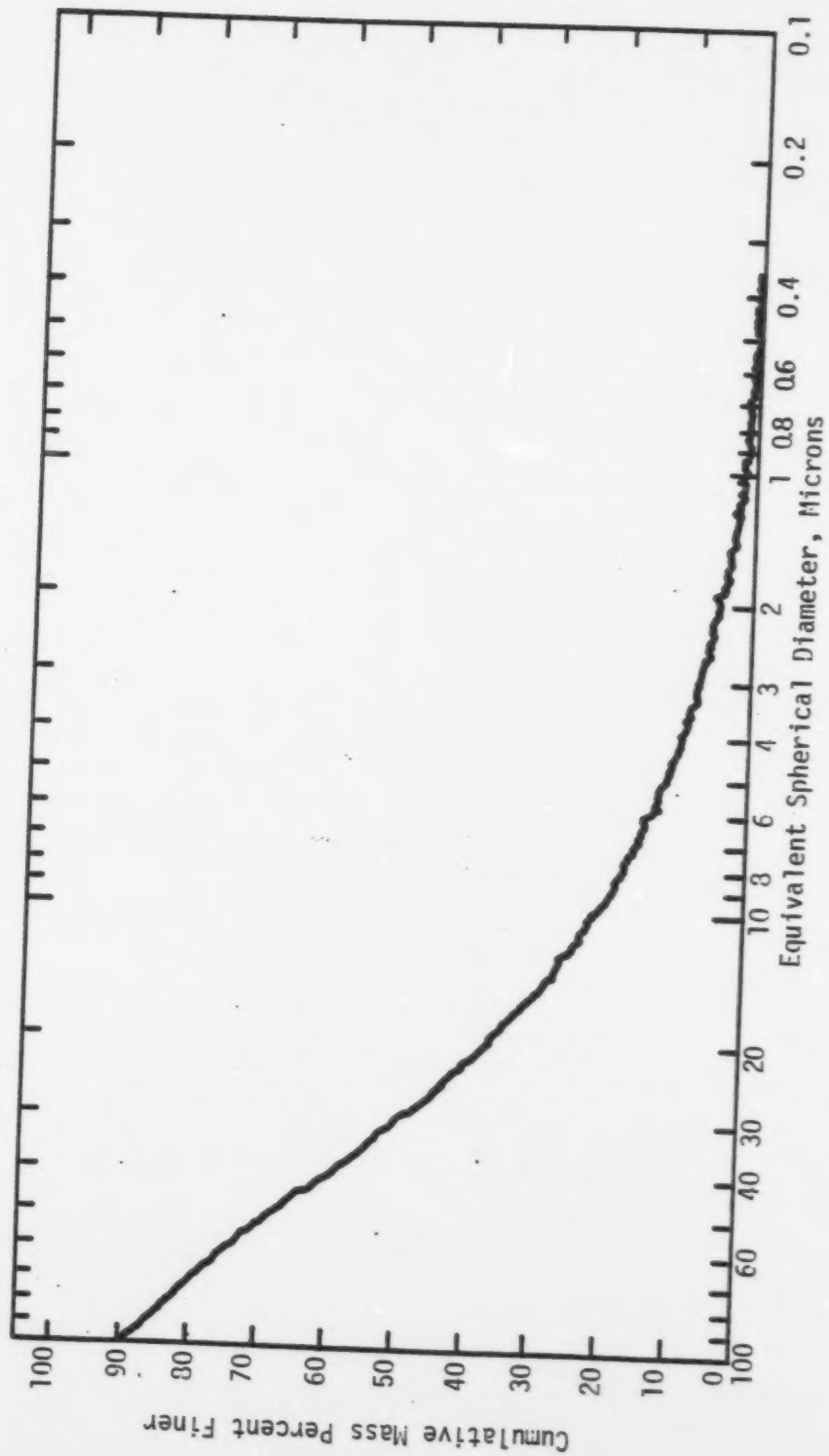


Figure C-5. Particle size distribution for Marble White 125, EER/BSF.

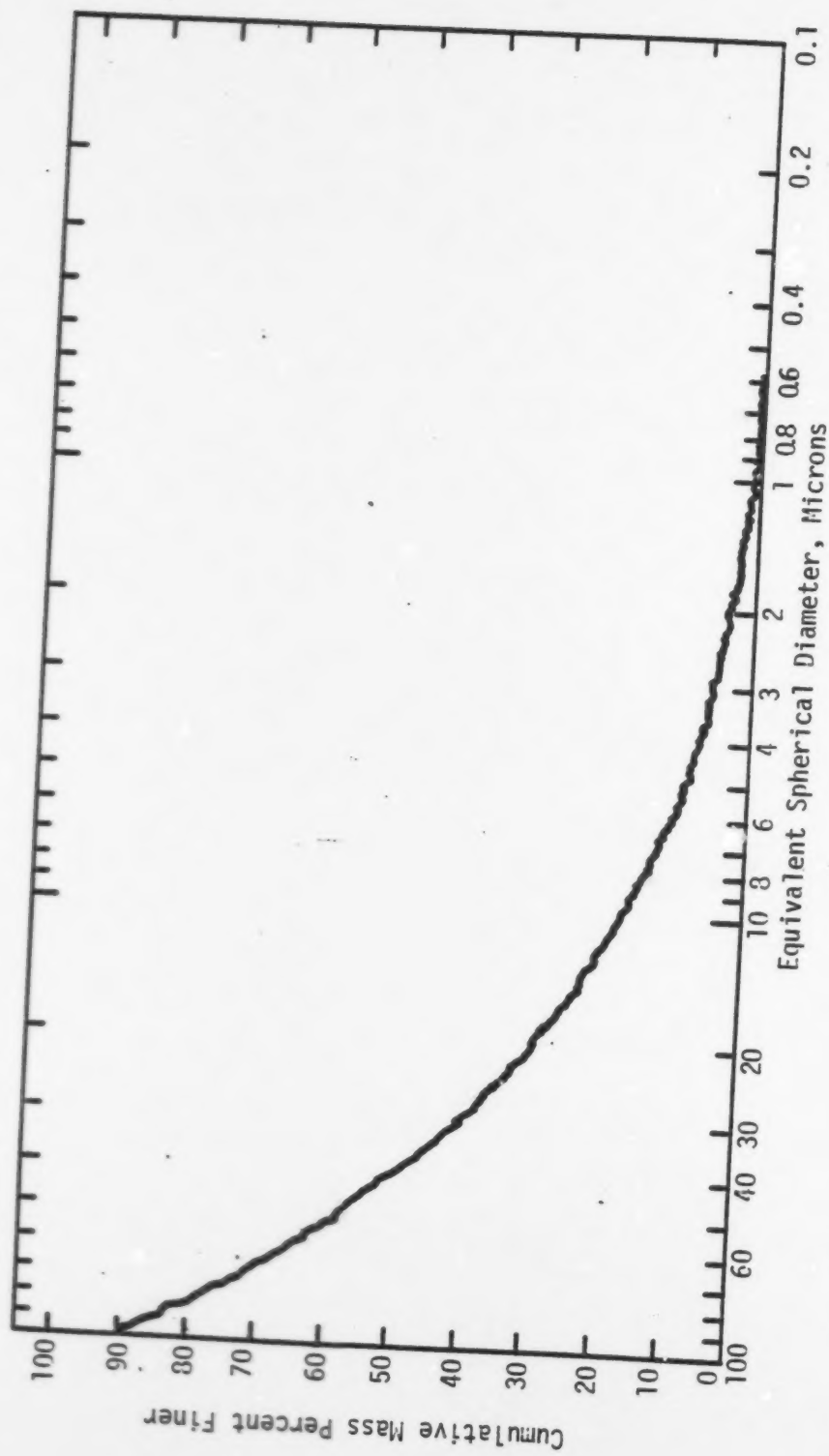


Figure C-6. Particle size distribution for Dolomite, EER/BSF.

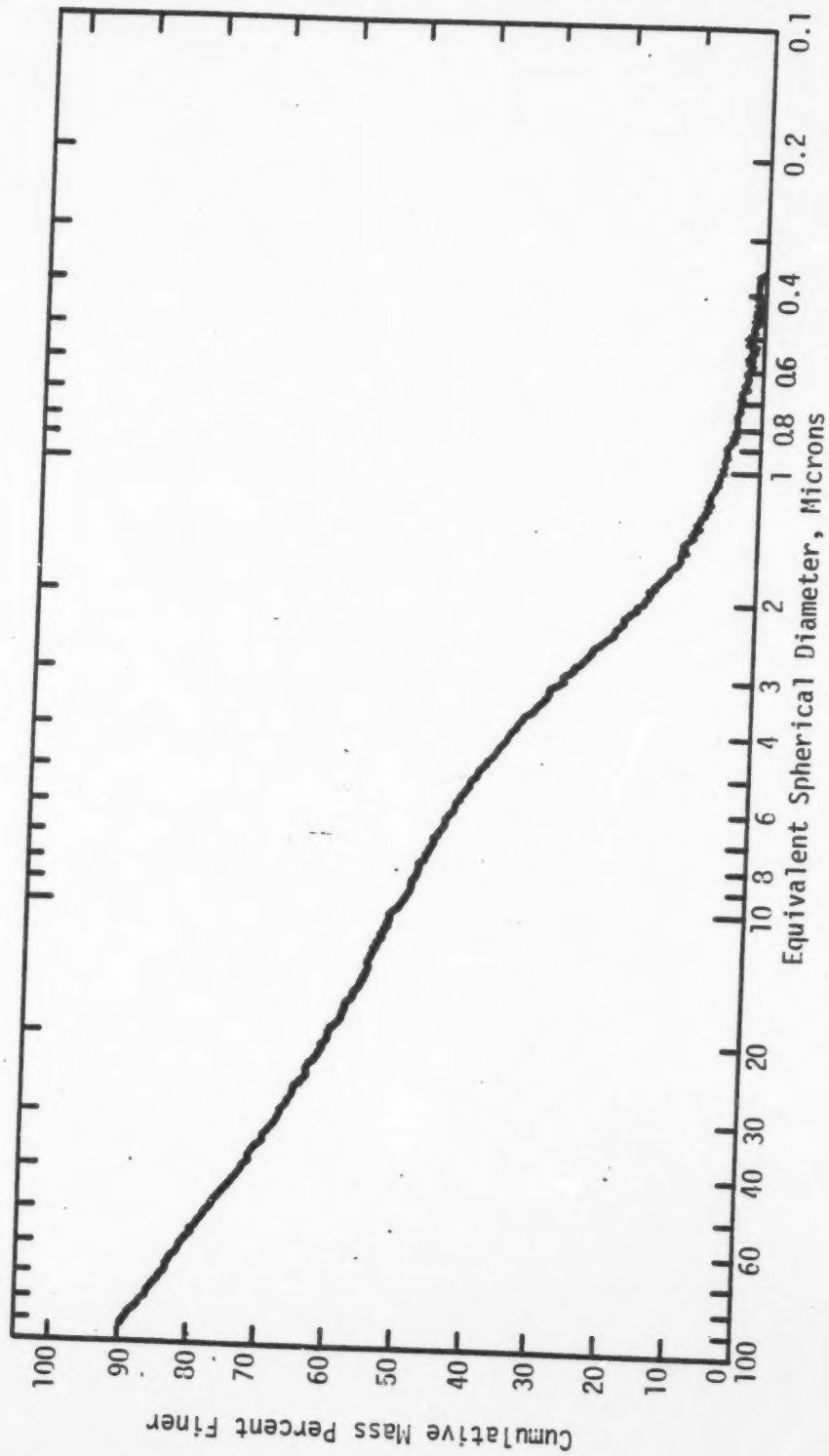


Figure C-7. Particle size distribution for Fredonia (coarse), EER/BSF.

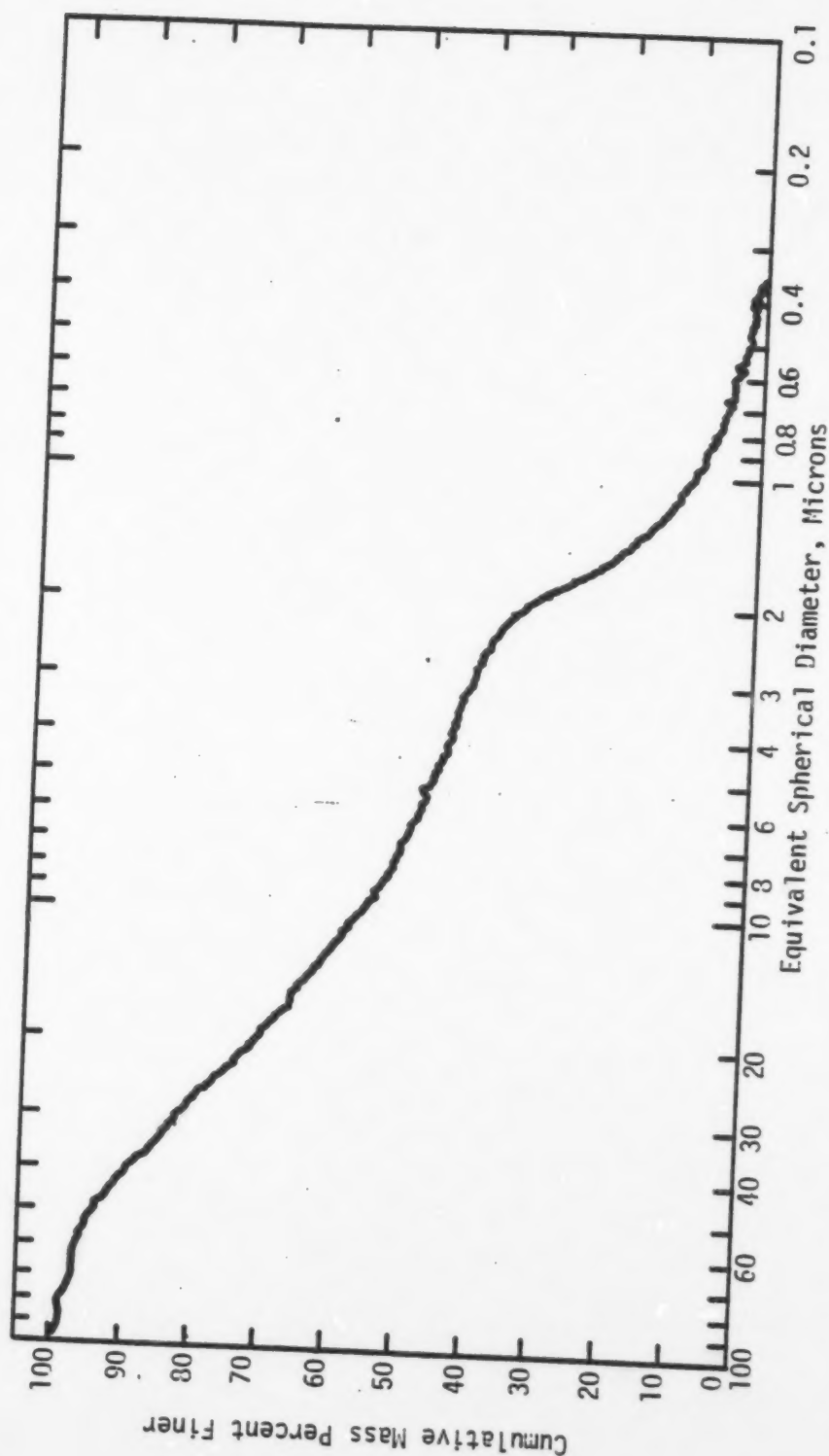


Figure C-8. Particle size distribution for Ca(OH)_2 Colton, EER/BSF.

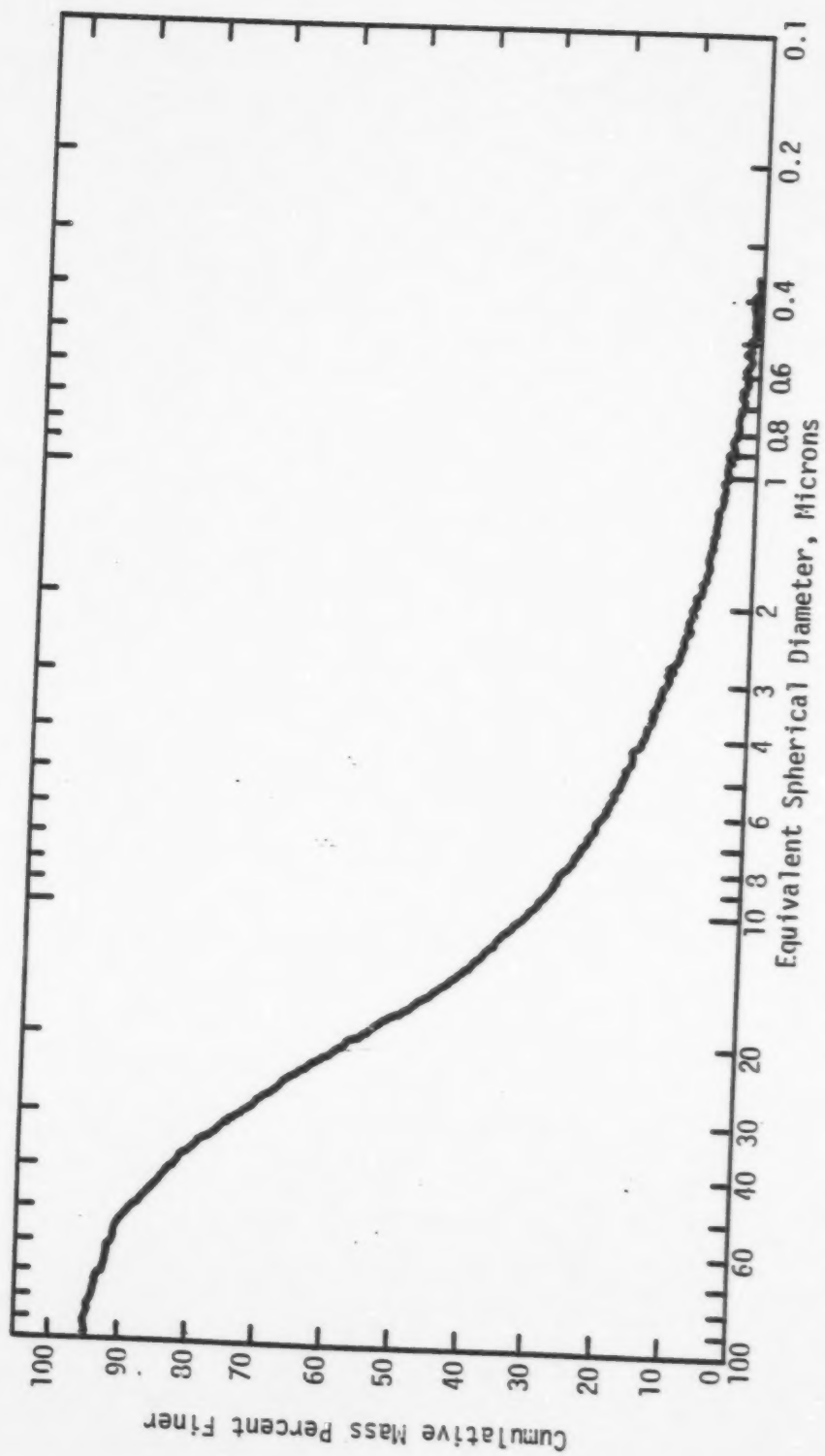


Figure C-9. Particle size distribution for CaCO_3 RWE, EER/BSF.

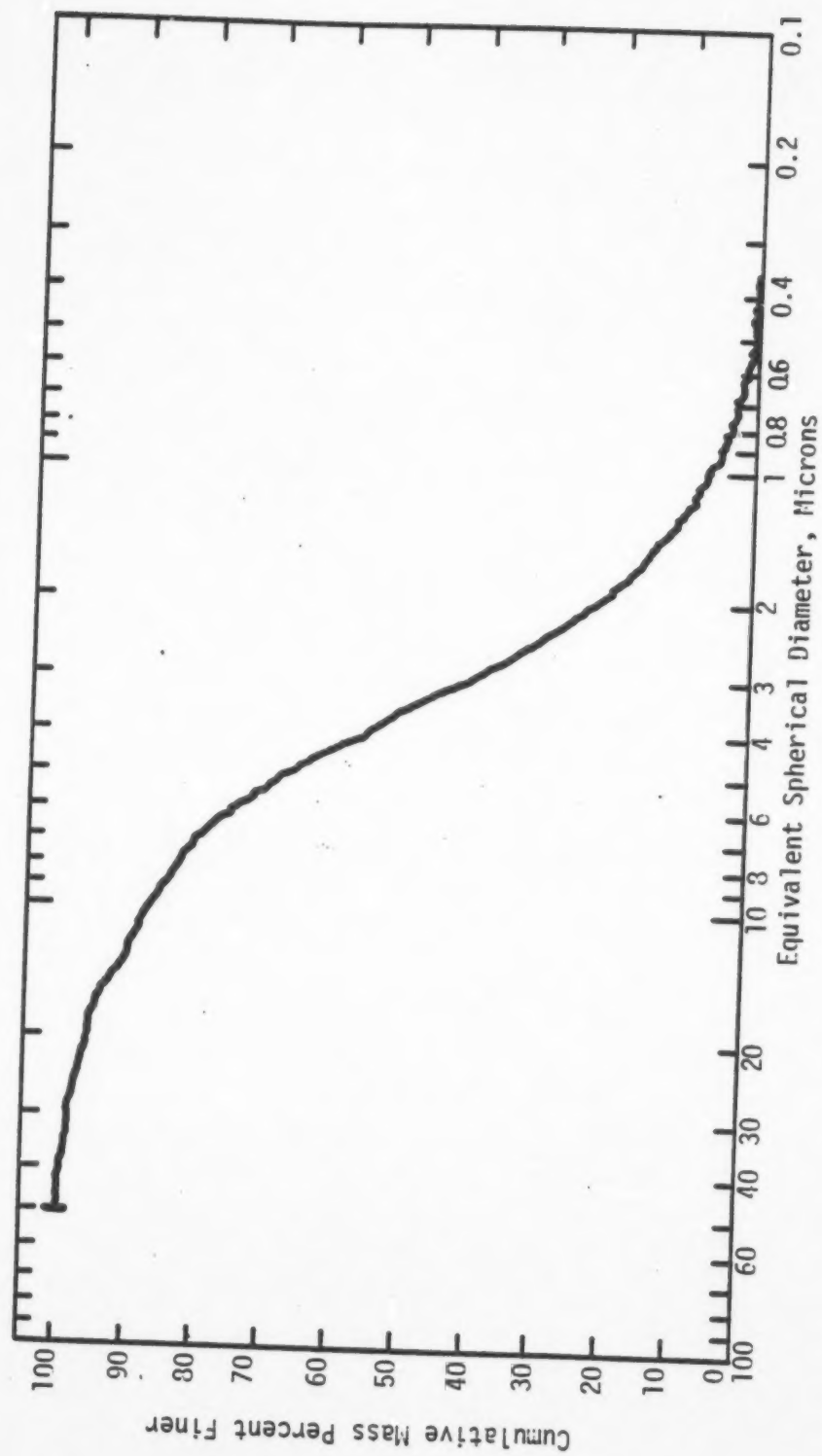


Figure C-10. Particle size distribution for Ca(OH)_2 RWE, EER/BSF.

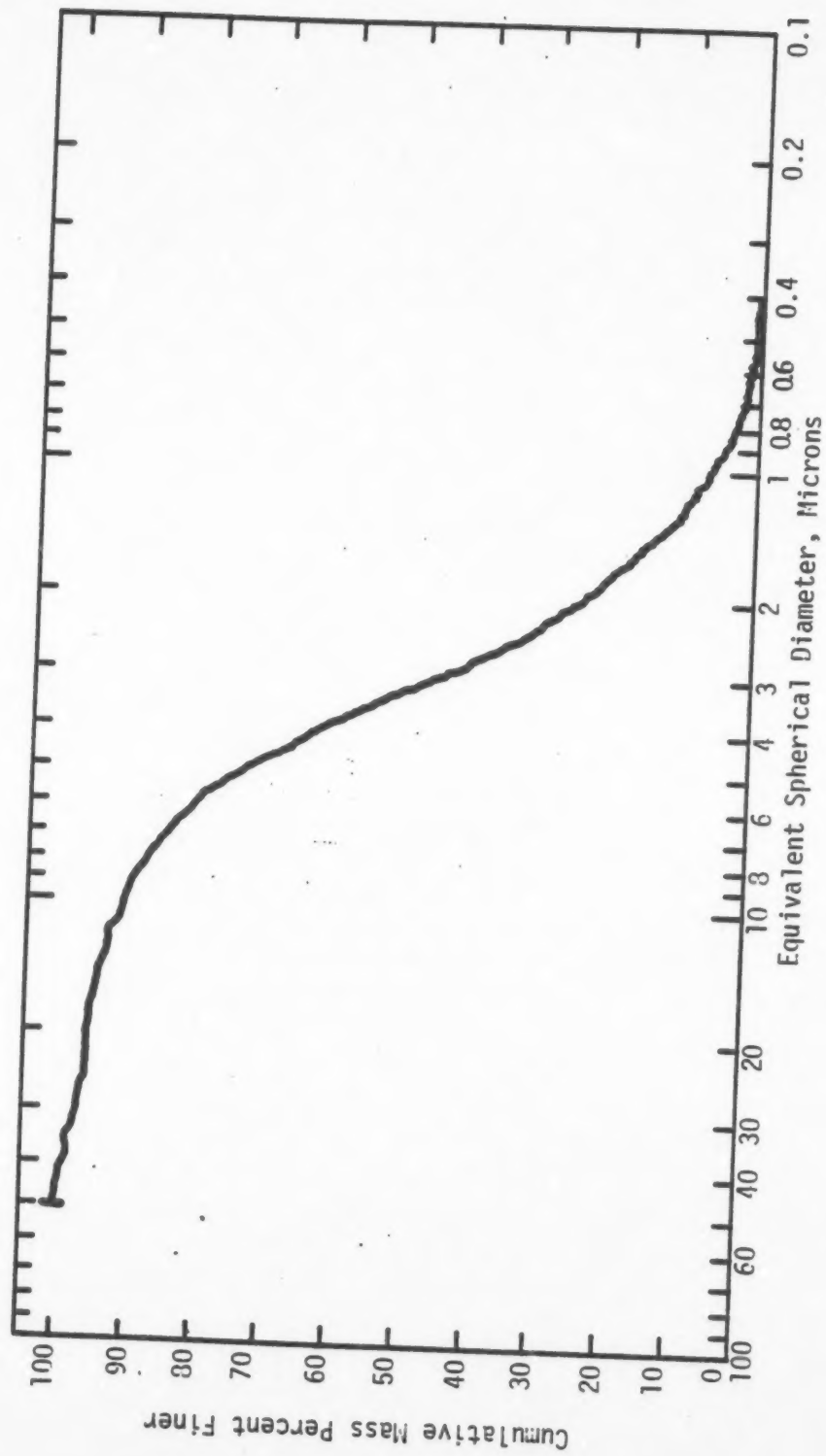


Figure C-11. Particle size distribution for Ca(OH)_2 (Act.) RWE, EER/BSF.

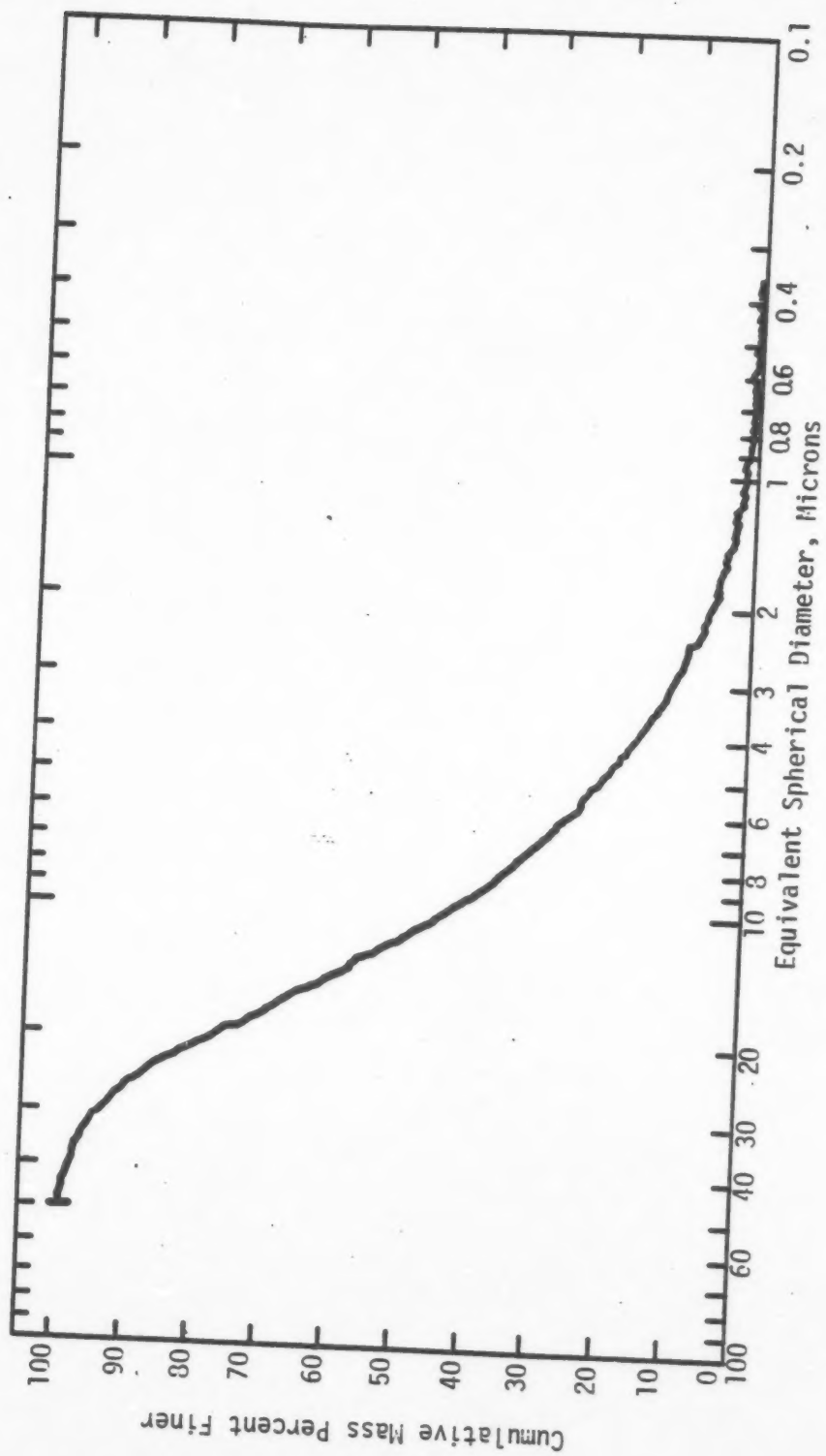


Figure C-12. Particle size distribution for Vicron 45-3, EER/BSF.

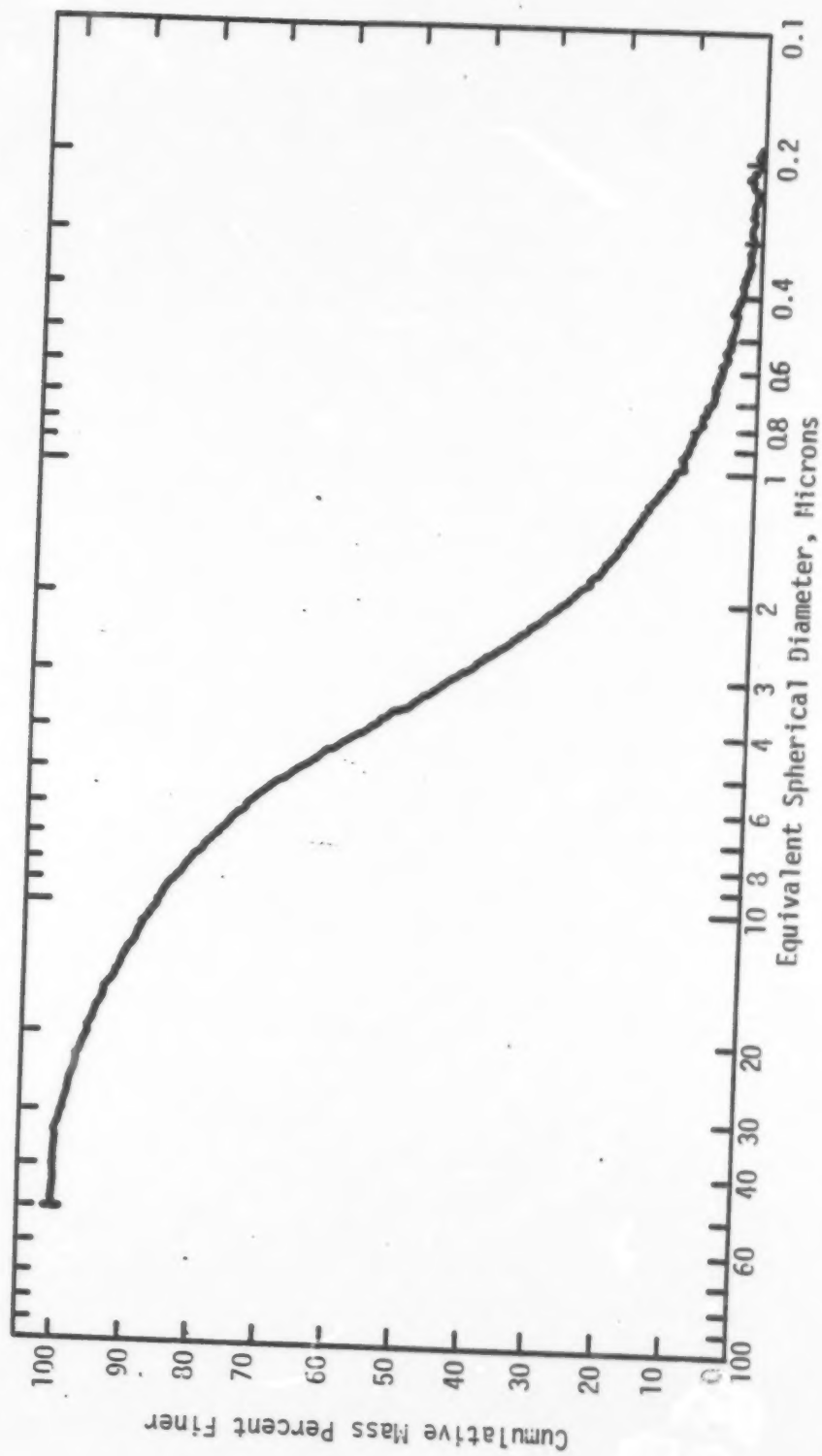


Figure C-13. Particle size distribution for Ca(OH)_2 German EER/BSF.

MINERAL ADDITIVE CHARACTERISTICS

SORBENT	IBEX BENTONITE	HYDRITE KAOLIN F4TD	HYDRITE KAOLIN PX	HYDRITE KAOLIN 1215	
Petrographic Charact.					
Type					
Composition	MINERAL	MINERAL	MINERAL	MINERAL	
Grain Size μm	SiO ₂	SiO ₂	SiO ₂	SiO ₂	
Top Size μm	Al ₂ O ₃	Al ₂ O ₃	Al ₂ O ₃	Al ₂ O ₃	
Mean Size μm					
Bottom Size μm		5.	0.68	1.5	
Density gm/cc					
Oil Absorption	1.0				
Surface Area		34.	43.	39.	
		7.	12.	8.	
Ignition Wt. Loss					
500°C					
1000°C	14.4	13.97	13.97	13.97	
SA (1000°C) m ² /gm					
Hydration Wt. Gain					
(1000°C)					
Acid Titration	9.7				
Chemical Comp. (%)					
Ca	7.43	0.035	0.035	0.035	
Al	4.234	10.15	10.15	10.15	
Si	18.837	21.17	21.17	21.17	
Fe	0.66	0.105	0.105	0.105	
Na		0.1	0.10	0.10	
Mg	5.97	0.150	0.150	0.150	
K		0.017	0.017	0.017	
Cr					
P					
Ti					
S		0.86	0.86	0.86	

SORBENT - MINERAL COMPOSITION

SORBENT - MINERAL	W Lost 950°C	CHEMICAL COMPOSITION (W%)										
		CaO	SiO ₂	Al ₂ O ₃	TiO ₂	Fe ₂ O ₃	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	CR	SO ₃
Vicron 45-3/Kaolin Flat D 1/2	22.57	19.6	38.60	32.14	0.60	0.34	0.65	0.06	1.21	0.11	0.004	0.16
Vicron 45-3/Kaolin Flat D 2/1	34.0	36.58	15.2	12.923	0.48	0.17	0.6194	0.1295	0.031		0.004	
Vicron 45-3/Kaolin 121 S 2/1	34.0	36.58	15.2	12.923	0.48	0.17	0.6194	0.1295	0.031		0.004	
Dolomite/Kaolin Flat D 10/3.5	38.5	21.8	12.33	10.20	0.373	0.294	14.92	0.136	0.08		0.20	
Dolomite/Kaolin 121 S 2/1	36.0	19.6	15.63	12.96	0.48	0.294	13.42	0.149	0.0759		0.18	
Marble White 125/Kaolin Flat D 2/1	32.1	36.58	15.2	12.923	0.48	0.17	0.6194	0.1295	0.031		0.004	
Marble White 125/Kaolin 121 S 2/1	32.1	36.58	15.2	12.923	0.48	0.17	0.6194	0.1295	0.031		0.004	
Vicron 45-3/Kaolin Flat D 1/1	29.0	27.46	22.72	19.28	0.72	0.203	0.52	0.164	0.033		0.004	
Dolomite/Kaolin Flat D 1/1	30.53	14.7	23.04	19.31	0.72	0.16	10.15	0.179	0.067		0.218	
Vicron 45-3/Bentonite 1/2	27.88	24.67	37.95	6.19	0.21	2.05	10.71	1.42	2.69	0.67	0.04	.11
Dolomite/Bentonite 1/2	25.3	16.7	27.13	10.75		1.36	13.29	0.03	0.031		0.145	

SORBENT MINERAL MIXTURES CHARACTERISTICS

SORBENT MINERAL	1000°C Ig Loss	S.A 10000°C	CHEMICAL COMPOSITION (IGNITED SAMPLE)										
			W%										
			CaO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	K ₂ O	MgO	TiO ₂	P ₂ O ₅	CrO ₂	SO ₃
Vicron 45-3	44.0	6.79	97.6	0.27	0.35	0.188	0.10	0.046	1.42			0.01	
Indiana 3 (Ash) + Vicron 45-3 Ca/S = 2.0	19.0		29.26	41.26	17.23	8.81	0.16	0.86	0.85	0.67	0.36	0.005	0.52
SWS Ash + Vicron 45-3 (1:1)	23.7		41.59	34.81	12.39	4.66	0.30	0.81	1.34	0.41	0.19		1.69
SWS Ash + Vicron 45-3 (3:1)	14.41		20.93	49.34	17.51	6.52	0.41	1.09	1.11	0.62	0.28		1.15
Bentonite + Vicron 45-3 (2:1)	27.88	.40	24.67	37.95	6.19	2.05	1.42	2.69	10.71	0.21	0.67	0.004	0.11
Kaolin + Vicron (1:1)	29.71	2.37	38.62	31.94	27.11	0.285	0.231	0.046	0.738	1.012		0.007	
Dolomite	47.1		57.18	1.54	0.49	0.57	0.17	0.18	39.02			0.848	
Indiana 3(Ash)+Dolomite Ca/S = 2	28.3		24.28	34.80	14.41	7.47	0.178	0.78	16.42	0.56	0.30	0.35	0.43
Dolomite + Bentonite (1:2)	25.3	0.89	24.08	39.06	15.47	1.96	0.043	0.045	19.12			0.209	
Dolomite + Kaolin (1:1)	31.2	6.49	21.42	33.53	28.11	0.43	0.261	0.097	14.78	1.04		0.317	

APPENDIX D -- QUALITY ASSURANCE

D.0 The collection and analysis of quality data has been the primary objective of this program. In order to ensure that the reported data is accurate, many quality assurance measures have been taken in all phases of the program. Most of the procedures and measurements used for data acquisition have been standardized by EPA or ASTM and those which have not are described in detail in this appendix.

D.1 Measurements Methods

D.1.1 Gas Species

Exhaust gas-phase species composition was measured using the BSF laboratory sampling systems. These systems were constructed in strict conformance with EPA performance specifications and their use helped ensure data quality. The species that were measured included: NO, NO₂, SO₂, CO, CO₂, all of which were measured by continuous gas analyzers.

Table D-1 lists the specific instruments and full-scale ranges. The instrument ranges have been selected to exceed the maximum expected concentrations by a small margin.

Gas phase species concentrations were measured on a routine basis at three locations in the Boiler Simulator Furnace. These locations - exit of radiant furnace, exit of post-flame cavity, and exit of convective section are indicated in Figure D-1. Phase discrimination probes (see Figure D-1) with water-cooled outer jackets, were used at all three sample locations. The probes supplied two gas streams simultaneously: the main, particle-laden stream, which was used for continuous monitoring of O₂, CO, CO₂, NO_x, and the side, nearly particle-free stream, which was used for SO₂ measurement.

TABLE D-1. CONTINUOUS GAS ANALYZERS, PILOT FACILITIES

Gas Measured	Type of Instrument	Manufacturer	Model No.	Range
NO, NO _x	Chemiluminescent	Thermo Electron Corp. (TECO)	10 AR	1000 RPM
CO	Nondispersive Infrared (NDIR)	Anarad, Inc.	AR500R	500 ppm
CO ₂	Nondispersive Infrared (NDIR)	Anarad, Inc.	AR500R	25 percent
O ₂	Paramagnetic	Beckman	755	10 percent
SO ₂	UV Absorption	DuPont	400	5000 ppm

(A) = Internally Staged
(B) = Externally Staged

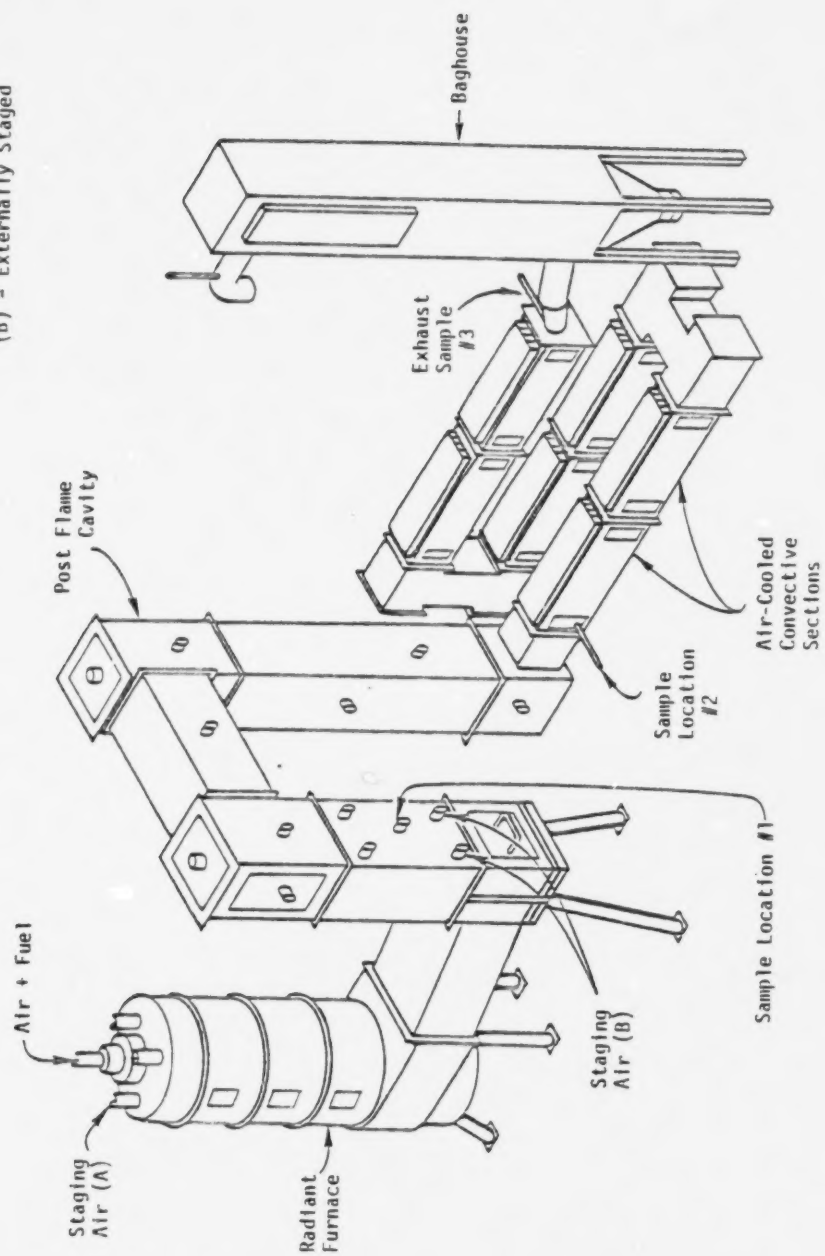


Figure D-1. Schematic of sample locations in boiler simulator furnace.

Sample conditioning for the two streams was somewhat different (see Figure D-2). The main sample (O_2 , CO, CO_2 , NO_x) was dried using an iced condenser, filtered, pressurized, filtered again and delivered to the continuous instrumentation listed in Table D-2. The SO_2 gas sample was transported in a heated Teflon line maintained above $115^\circ C$ under vacuum to a heated filter followed by a permeation tube drier. The permeation tube drier selectively removes water vapor from the gas sample. Dry air was used as the dry gas medium in the permeation drier. The sample was then pressurized and delivered to the analytical system (see Figure D-3). SO_2 concentration was measured using a non-dispersive ultraviolet instrument manufactured by DuPont.

The sample train for the continuous analyzers is shown in Figure D-4. All materials in contact with the sample gas are limited to glass, stainless steel, Teflon and a small amount of Kel-F (valve seals). These materials have been demonstrated to be essentially non-reactive to the species being measured over the temperature range involved in this system (32 to $200^\circ F$). The sample probes are water-cooled stainless steel due to the high gas temperature at the sampling point. Each probe is connected to a stainless steel cyclone filter which removes any water condensed in the probe, as well as particulate. The sample gas existing the cyclone is transported about 100 feet through a Teflon line, filtered and dried as shown. The sample pumps are Teflon-lined and the sample flow rates are maintained at several times the instrument requirements to minimize sample line residence time. Excess flow is bypassed to a vent.

In flame measurements were taken with standard water-cooled suction probes inserted directly into the flame. This data was collected at a sufficiently close spacing to define a smooth curve throughout the flame zone. EER's experience indicates that measurements spaced from 1 to 2 inches apart are sufficient for determination of the concentration gradients. Figure D-5 illustrates the O_2 , CO, and CO_2 profiles across the furnace.

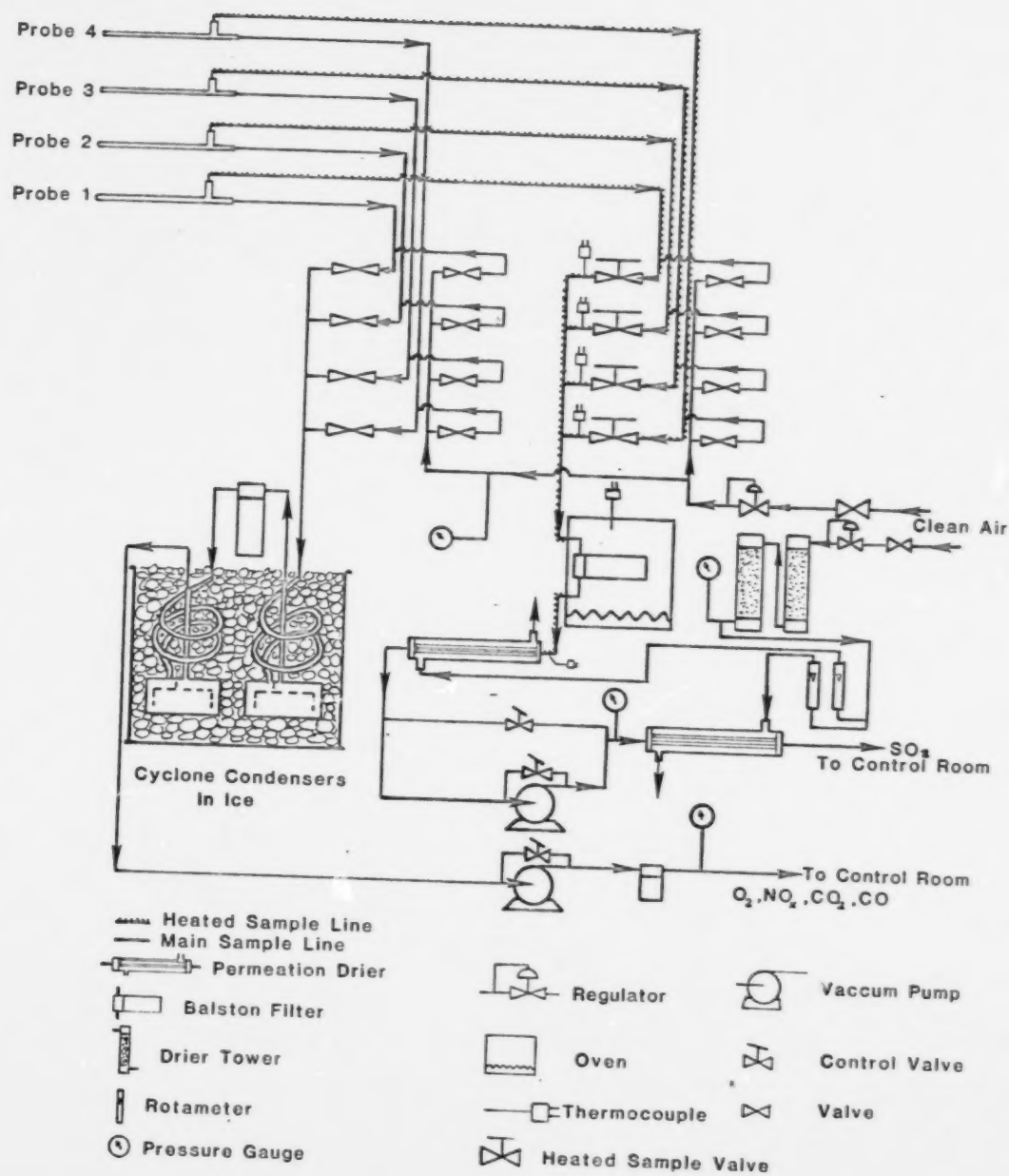


Figure D-2. Sample conditioning system, BSF.

TABLE D-2. CONTINUOUS GAS ANALYZERS, BSF

Measure-	Probe and Conditioning	Analytical Method/ Instrument	Range
O ₂	Standard or phase discrimination. - Continuous	Paramagnetic Beckman	x, 10%
CO ₂	"	Nondispersive infrared (Anarad)	
CO	"	"	500 ppm
NO _x	"	Chemiluminescent (TECO)	1000 ppm
SO ₂	Phase discrimination, continuous or batch	Nondispersive ultraviolet (DuPont) or GC (as below)	4000 ppm
H ₂ S	Phase discrimination or gas stream from solids	Gas chromatograph with flame--photometric detector	5000 ppm
COs	"	"	"

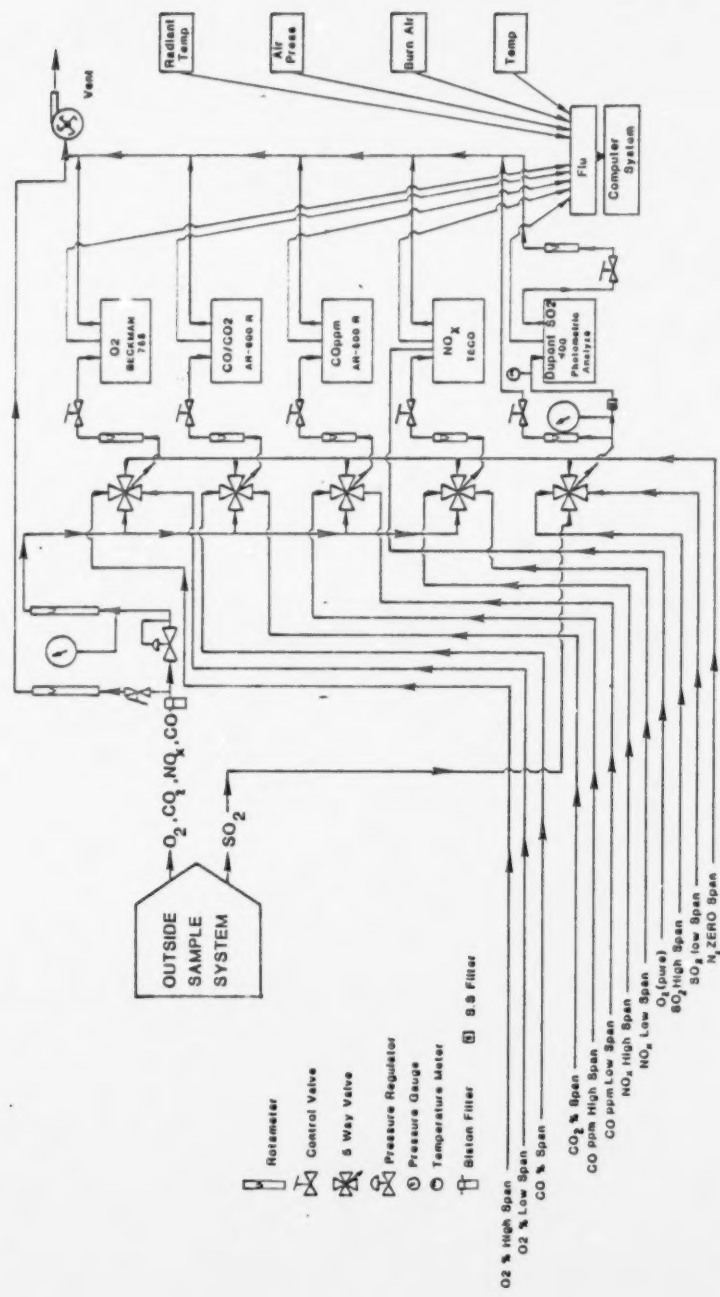


Figure D-3. Analytical system, BSF.

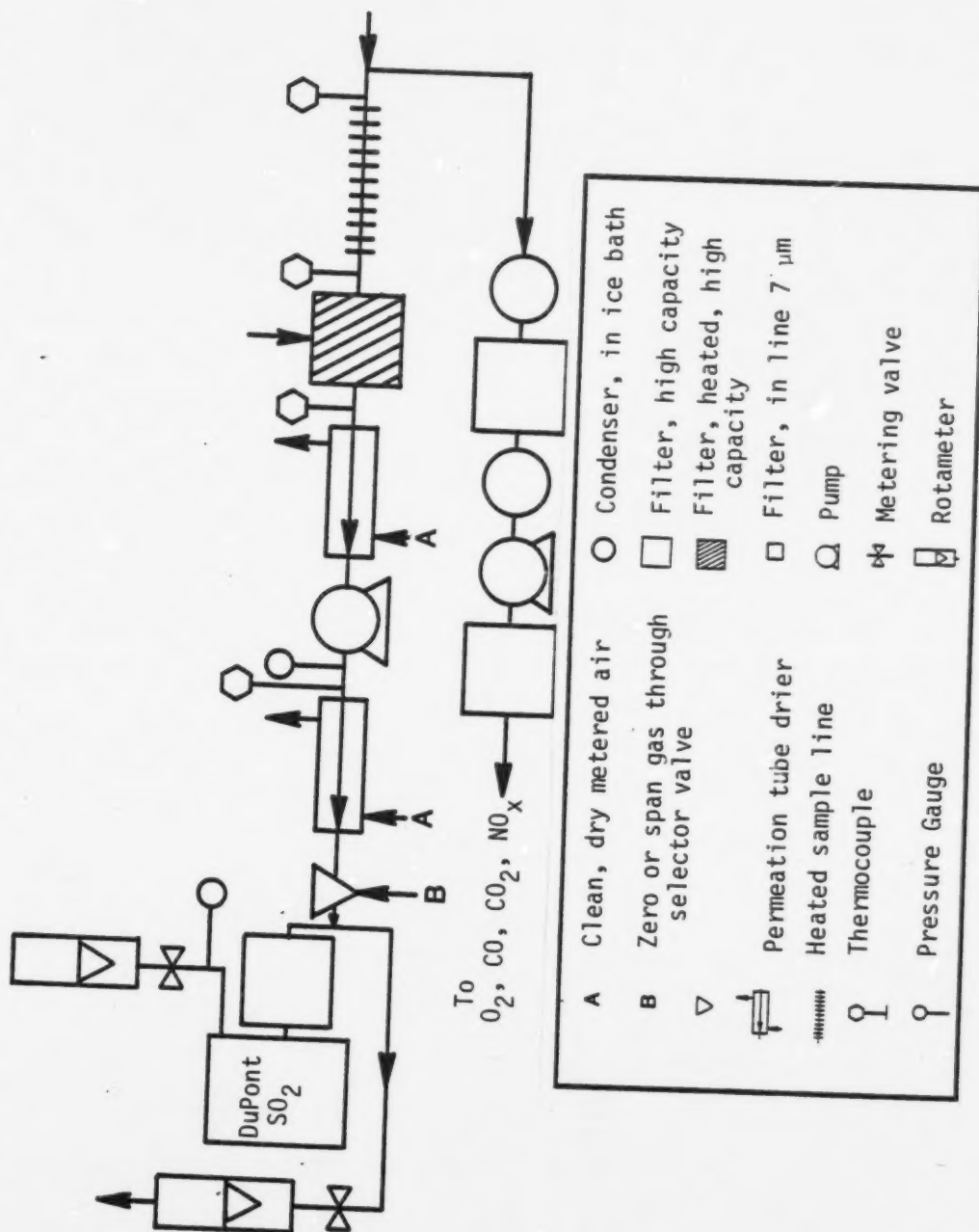


Figure D-4. Gas phase measurement system.

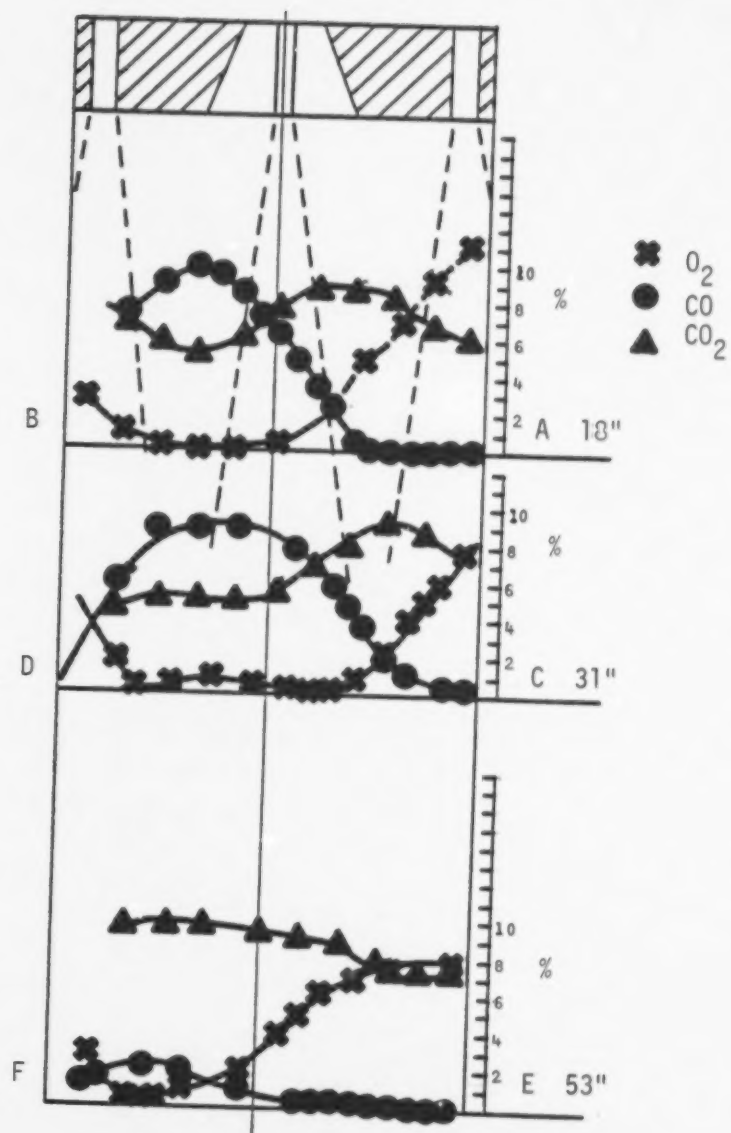


Figure D-5 Gas species profiles, natural gas flame.

D.1.2 Solids Species

Solid samples were taken from the furnace in two ways: isokinetically with a filter-tipped, water-cooled probe, and non-isokinetically with a water-cooled "grab sample" probe and glass cyclone. In the post-flame cavity and convective section the isokinetic sampling system consisted of a probe made at the International Flame Research Foundation (IFRF), and a heated Teflon sample line followed by a pump, dry gas meter, pressure gauge, and rotameter for the measurement of the sample flow rate. The grab sample was taken from the furnace with a standard, stainless-steel, water-cooled probe and the solids removed from the sample with a glass cyclone. Detailed schematics of both of these systems are given in Appendix B (Figure B-10 and B-11).

Because the IFRF probe was too large for any of the sample ports in the radiant furnace, a new solids sampling probe was fabricated. Sampling for solids in the flame with reactive solids (sorbent) ash and char requires a probe which quenches the sample rapidly (to prevent hot, sticky ash from plugging the probe) without allowing condensation on the probe walls. The sample gas temperature profile was measured and the gas sample flow rate and cooling water-flow rates were adjusted to give sufficient quenching without condensation for different sample locations and furnace conditions (natural gas/coal flame). Solid samples were taken at the centerline of the radiant furnace at several axial locations from the Indiana coal flame and the natural gas flame. Schematic diagrams of the new solids sampling probe and the sample conditioning system are also given in Appendix B (Figures B-12 and B-13).

D.3 Calibration Procedures

Calibration procedures and frequency for each measurement system are listed in Table D-3. As shown in the table, standard calibration procedures were used for each system. Each system was calibrated at the frequency shown in the table to ensure the accuracy of the measurements are traceable to the calibration standards.

D.1.2 Solids Species

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TABLE D-3. CALIBRATION PROCEDURES

Measurement Parameter	Calibration Procedure	Calibration Frequency	Calibration Standard	Reference
Fuel Composition: Carbon Hydrogen Nitrogen Ash Moisture Sulfur	Standard Samples Standard Sample	Daily Daily	Known quantity of 100% acetanilide Certified sulfur	Perkin Elmer 240B Operating Manual Leco SC 32 ASTM E 11
Fuel Flowrate/ Distribution	Weigh feed over time with independent balance	Monthly	Standard Weights	
Combustion Air Flowrate/Distribution	Compare with EPA Method 2 or dry gas meter	Biannually	EPA Method 2 or calibrated dry gas meter	Federal Register, Vol. 42, No. 160, August 18, 1977, pp 41754-41788
Sorbent Flowrate	Weigh feed over measured time with independent balance	Daily	Standard weights	
Exhaust Gas Composition NO, NO ₂ , O ₂ , CO, CO ₂ , SO ₂	Compare to standard compressed gas	Daily	EPA Protocol 1 Gases or custom gas blends	EPA EMSL Protocol No. 1, June 1, 1978

Each of the continuous monitoring instruments was calibrated with three gases: a zero gas and two span gases at approximately 50 and 90 percent of span except in the case of SO₂ where the concentrations were chosen to match expected SO₂ levels during experimental runs. Table D-4 lists the span gases used to calibrate instruments. The daily procedure for instrument calibration is given below.

- 1) Turn on control room exhaust fan.
- 2) Switch 4-way valves on instrument sample panel to down (N₂) position.

Adjust needle valves to get 2 s.c.f.h. flow to instruments. Turn DuPont 4-way valve counterclockwise to N₂, pressure gauge should read .8 psig.

- 3) Switch Beckman 755 to 10 percent range/scale.
- 4) Install pens in chart recorder according to proper color. With measurement switches off, adjust pens to zero position. Make sure pens are properly seated and turn on 6 measurement switches. Note in following procedures that the instrument zero and spans should match zero and span on the chart recorder.
- 5) Adjust instrument's zero knobs to make instruments read zero. Note: There is no front panel readout for the DuPont. Adjust course zero knob on DuPont so that DuPont record pen corresponds with zero on the chart paper.
- 6) O₂: Turn Beckman 755 4-way valve to the right (high span position). Adjust needle valve to 2 s.c.f.h. Adjust span knob to make front panel meter read 8.0% (or concentration of span gas). Switch back to N₂ gas

TABLE D-4. CALIBRATION GASES

Gas	Concentration	Percent of Full-scale	Balance Gas	Grade
NO	500 ppm	50	Nitrogen	Certified Standard
NO	900 ppm	90	Nitrogen	Certified Standard
SO ₂	2100 ppm	52	Air	Certified Standard
SO ₂	520 ppm	13	Air	Certified Standard
CO	250 ppm	50	Nitrogen	Certified Standard
CO	450 ppm	90	Nitrogen	Certified Standard
CO ₂	12.5%	50	Nitrogen	Certified Standard
CO ₂	22.5%	90	Nitrogen	Certified Standard
O ₂	5%	50	Nitrogen	Certified Standard
O ₂	9%	90	Nitrogen	Certified Standard

and reset zero. Switch range knob to 25% range/scale and turn 4-way valve up (sample position). Verify air flow.

- 7) Turn Anarad AR-500R 4-way valve to the span position, adjust needle valve to get 2 s.c.f.h. Adjust span knob to make front panel meter read 403 ppm (or concentration of span gas) re-check zero. Turn 4-way valve to up sample position.
- 8) CO/CO₂: Turn Anarad AR-600R 4-way valve to the CO₂ span position (right). Adjust needle valve to get 2 s.c.f.h. Adjust CO₂ span knob to make front panel meter read 18.2% CO₂ (or concentration of span gas). Turn 4-way valve to the left (high CO span). Adjust needle valve to get 2 s.c.f.h. flow. Adjust CO span knob to make CO front panel meter read 8.9% or span concentration re-check zero. Turn 4-way valve to up sample position.
- 9) NO_x: Turn thermo-electron (TECO) 4-way valve to span position (right). Adjust needle valve to get 2.0 s.c.f.h. flow. Adjust "calibrate" knob to make front panel meter read 840 ppm (or concentration of span gas) re-check zero. Turn 4-way valve to up (sample) position.
- 10) Turn DuPont 4-way valve clockwise to the right high span (SO₂) position. Adjust flow to .8 psig. on "Range B", the DuPont analyzes SO₂ concentrations from 0-4000 ppm so set the span knob so that the DuPont recorder pen reads span gas concentration. Check low-span. Turn 4-way valve to sample position.
- 11) Sample gas can now be analyzed. When taking a sample the main

bypass rotometer should read between 50-100 c.f.h. with the back pressure regulator set at 4 psi. DuPont bypass rotometer should read 5-10 s.c.f.h. and pressure should be .8 psig. The DuPont pressure may be changed by adjusting the sample or bypass flow rates.

D.3 Analytical Procedures

Analytical procedures for each measurement are listed in Table D-5. EPA standard procedures are used, where appropriate. Where possible, the remaining measurements use other standard procedures, as shown in the table. TD-5

Table D-6 shows the expected and actual values for precision, accuracy, and completeness for the continuous gas analyses and other routine measurements. TD-6

D.4 Standard Systems Checks and Preventative Maintenance

At the beginning of each day of testing several routine system checks and maintenance tasks are performed to ensure that the systems are operating properly.

Initially, the sample system is cleaned, checked for leaks, and inspected for routine maintenance. A detailed description of these procedures is given below:

- 1) Filters: The two long Balston filter cartridges are the farthest most upstream filters and should be changed as needed, every eight hours of running time, or once a day. The two short filters, close all the valves on the main sample side of the 4-port manifold panel. This insures that there is no air flow through the filter housing. Take filter housing apart and replace paper filter. When reassembling filter, make sure housing seats properly onto gaskets. Add a little vacuum grease now and then to keep gaskets pliable.

TABLE D-5. ANALYTICAL PROCEDURES

MEASUREMENT PARAMETER	ANALYTICAL PROCEDURE	REFERENCE
Fuel Composition		
Carbon	} Sample combusted, interferences absorbed, and elements detected by thermal conductivity	Perkin Elmer 240 B Operating Manual
Hydrogen		
Nitrogen		
Ash		
Moisture		
Sulfur	Sample combusted and resulting SO ₂ detected by infrared	Leco SC 32 Operating Manual
Heating Value	Adiabatic Bomb Calorimeter	ASTM D-2015
Fuel Size Distribution	Sieve Analysis	ASTM D-197
Combustion Air Flow-rate/Distribution	Rotameter or pressure differential across laminar flow elements	Dwyer Rotameter or inclined manometer operating instructions
Combustion Air Temperature	Thermocouple	EPA Method 2
Exhaust Gas Composition		
NO, NO ₂	Chemiluminescent Analyzer	Teco Model 10 Operating Manual
O ₂	Paramagnetic Analyzer	Bechman 755 Operating Manual
CO, CO ₂	Infrared Analyzer	Anarad AR 500 Operating Manual
SO ₂	Ultraviolet Analyzer	DuPont 400 Operating Manual

TABLE D-5. (Continued)

MEASUREMENT PARAMETER	ANALYTICAL PROCEDURE	REFERENCE
Exhaust Gas Composition (Continued)		
SO ₃	Acid/Base Titration	"Process Measurement Procedures, Sulfuric Acid Emissions," IERL Contract No. 68-02-2165, Task No. 13, February 1977
Particulate	Gravimetric	EPA Method 5
Moisture	Gravimetric	EPA Method 4
In-Furnace Sulfur Gas Species	Gas Chromatograph With FPD	See Text
Furnace Gas Temperature	Suction Pyrometer	
Particulate Composition		
Carbon	} Sample combusted, interferences absorbed, and elements detected by thermal conductivity	Perkin Elmer 240 B Operating Manual
Hydrogen		
Nitrogen		
Ash		
Calcium	Chelatometric Titration	ASTM D 2795
Sulfur	Sample combusted, and resulting SO ₂ detected by infrared	Leco SC 32 Operating Manual
Sorbent Composition		
Calcium	} Atomic Absorption	ASTM D 3682
Sodium		
Magnesium		
Potassium		

TABLE D-5. (Continued)

MEASUREMENT PARAMETER	ANALYTICAL PROCEDURE	REFERENCE
Sorbent Flowrate	Volumetric	Micromeritics Sedi-graph Operating Manual Quantasorb Surface Area Analyzer Operating Manual
Sorbent Size Distribution	X-Ray Diffraction	
Sorbent Surface Area	Condensation of N ₂ on sample followed by desorption and analysis of N ₂ by thermal conductivity	

TABLE D-6. EXPECTED AND ACTUAL VALUES FOR PRECISION, ACCURACY, AND COMPLETENESS FOR BSF MEASUREMENTS

Measurement	Precision (%)		Accuracy (%)		Completeness (%)	
	Actual	Goal	Actual	Goal	Actual	Goal
NO, NO _x (Chemiluminescent)	1.4	2	14.2	20	95	90
CO (NDIR)	0.4	2	No. Std.	20	95	90
CO ₂ (NDIR)	0.8	2	6.7	20	95	90
O ₂ (Paramagnetic)	0.5	2	11.2	20	95	90
SO ₂ (UV Absorption)	0.2	2	8.1	20	95	90
Fuel Composition						
Carbon	.24	2	0.8	2	95	90
Hydrogen	1.38	5	0.6	5	95	90
Nitrogen	2.13	10	1.9	10	95	90
Ash	0.33	10	1.42	10	95	90
Moisture	2.55	10	8.71	10	95	90
Sulfur	2.36	10	0.55	10	95	90
Heating Valve	--	2	0.39	2	--	90
Fuel Size	2.0	2	2.0	3	90	90
Combustion Air Flowrate	0.11	5	2.7	5	100	100
Sorbent Feedrate	--	2	--	2	100	90
Coal Feedrate	2.3	5	4.1	5	100	100
Gas Temperatures	1.0	5	1.7	5	98	90

- 2) Cyclone Condensers: Each day drain the water collected in the two condensers. The Teflon tubing is long enough to allow the drain nuts to be removed without undoing the tubing. Remove one of the drain plugs and open a valve on the 4-port manifold panel to blow-out any left-over condensate. Replace plug and repeat with other condenser. Then fill bucket with ice-water to cover condensers. Keep a solution of ice-water in the bucket at all times when sampling. Failure to keep the condensers cold will result in water condensing in the sample and instrument lines.
- 3) Drierite Towers: Verify that the moisture capturing capability of the Drierite has not been exhausted (indicated by color change from blue to pink) if it has, change Drierite material.
- 4) Leak Test: Close main and heated sample valves on 4-port manifold panel. Close 4-way valves on instrument panel by turning them 45° from vertical. Open Beckman 4-way valve to sample manifold position and open needle valve all the way. Screw back pressure regulator all the way. Open DuPont 4-way valve to sample position and open needle valve all the way. Close DuPont bypass valve (inside middle cabinet). Turn on sample pumps. Verify that there is no flow on the Beckman rotometer and that the back pressure regulator reads zero. There should also be no flow on the SO₂ sample rotometer. If there is flow through the Beckman rotometer, there is a leak in the main sample line. If there is flow through the DuPont rotometer there is a leak in the heated sample line. To trace leaks, turn off sample pumps, and open a main sample valve on the 4-port manifold panel to pressurize the main sample system. To pressurize the heated side, open a heated sample valve and its corresponding blow-back valve. The main and heated systems may now be leak tested with bubble solution. When both sample systems are leak-tight, reset the back pressure to 4 psi and reset the DuPont bypass and instrument flow valves.

In order to keep a track record of the instruments and span gases and of furnace conditions, routine information is logged each day in special data books. The purpose of the books is to maintain records should any questions arise from test results. Figure D-6 is a typical span gas inventory sheet. The table includes date, each instrument span gas reading, and pen number or color for reference to data traces. Figure D-7 is used to log furnace conditions in terms of pressures, temperatures, and fuel and air loads.

After the sampled system has been prepared and the instruments calibrated, an O_2 mass balance, or leak check, of the entire furnace system is performed. With natural gas firing, the on-line computer calculates the expected exhaust oxygen concentration based on natural gas and air calibration curves. The computer calculated O_2 is also checked each day with a hand-held calculator. If all systems are operating properly, O_2 concentrations usually match within 0.2 percent (this depends somewhat on variation in the fuel composition). Oxygen concentrations higher than expected may indicate sample system leaks upstream of the sample manifold or leaks into the gas delivery system. O_2 concentrations lower than expected indicate leaks in the air delivery system. Leak checks were performed at all three furnace locations to ensure that oxygen in the flue gas did not change due to furnace leaks.

D.5 Special Systems Checks

Throughout the course of this testing program, several independent or special checks were performed to ensure data quality.

A comparison of standard measurements (EPA Method 7) and the DuPont instrument was made for SO_2 samples. Wet measurements of SO_2 using controlled condensation followed by hydrogen peroxide scrubbing were made during normal experiments. Table D-7 summarizes the SO_2 measurement data. In general, the agreement was good between the two methods.

Periodic checks were also made for solids analysis, notably for sorbent size distribution and fuel analysis. Figures D-8 and D-9 show typical

Figure D-7. Furnace log data sheet.

TABLE D-7
COMPARISON OF WET AND INSTRUMENT
SO₂ CONCENTRATIONS

Date	Fuel	Sample #	SO ₂ Dupont	SO ₂ Wet
1/14/83	Nat. Gas/H ₂ S	1	1610	1860
1/18/83	Nat. Gas/H ₂ S	1	1097	1072
1/18/83	Nat. Gas/H ₂ S	2	404	334
1/19/83	Nat. Gas/H ₂ S	2	523	556
1/19/83	Nat. Gas/H ₂ S	3	519	564
1/19/83	Nat. Gas/H ₂ S	4	486	550
1/26/83	Nat. Gas/H ₂ S	1	398	364
1/26/83	Nat. Gas/H ₂ S	2	451	370
1/20/83	Indiana 3	1	742	713
1/20/83	Indiana 3	2	778	511
1/20/83	Indiana 3	3	855	848
1/21/83	Indiana 3	1	685	676

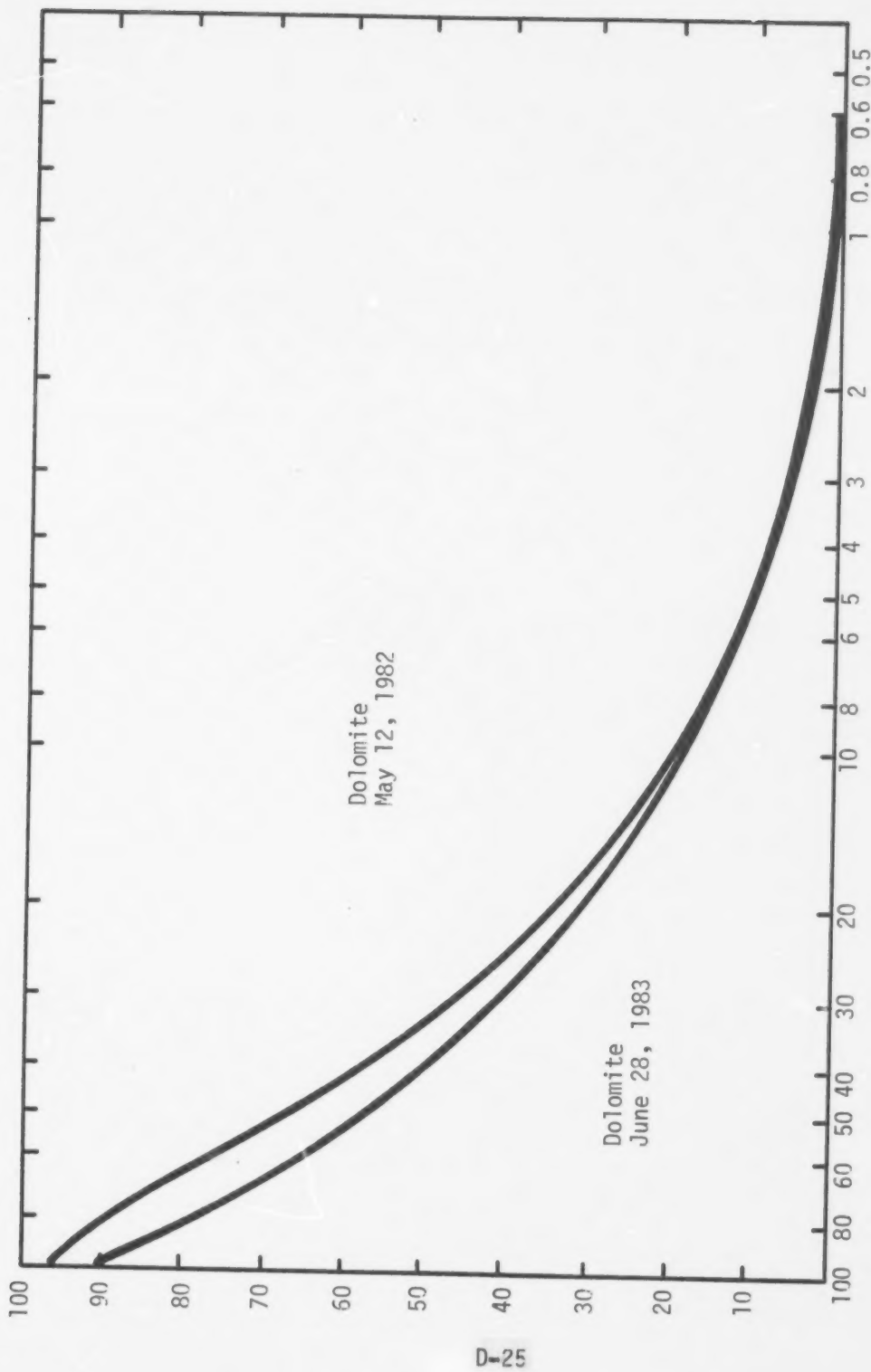


Figure D-8. Comparison of Dolomite Size Distribution

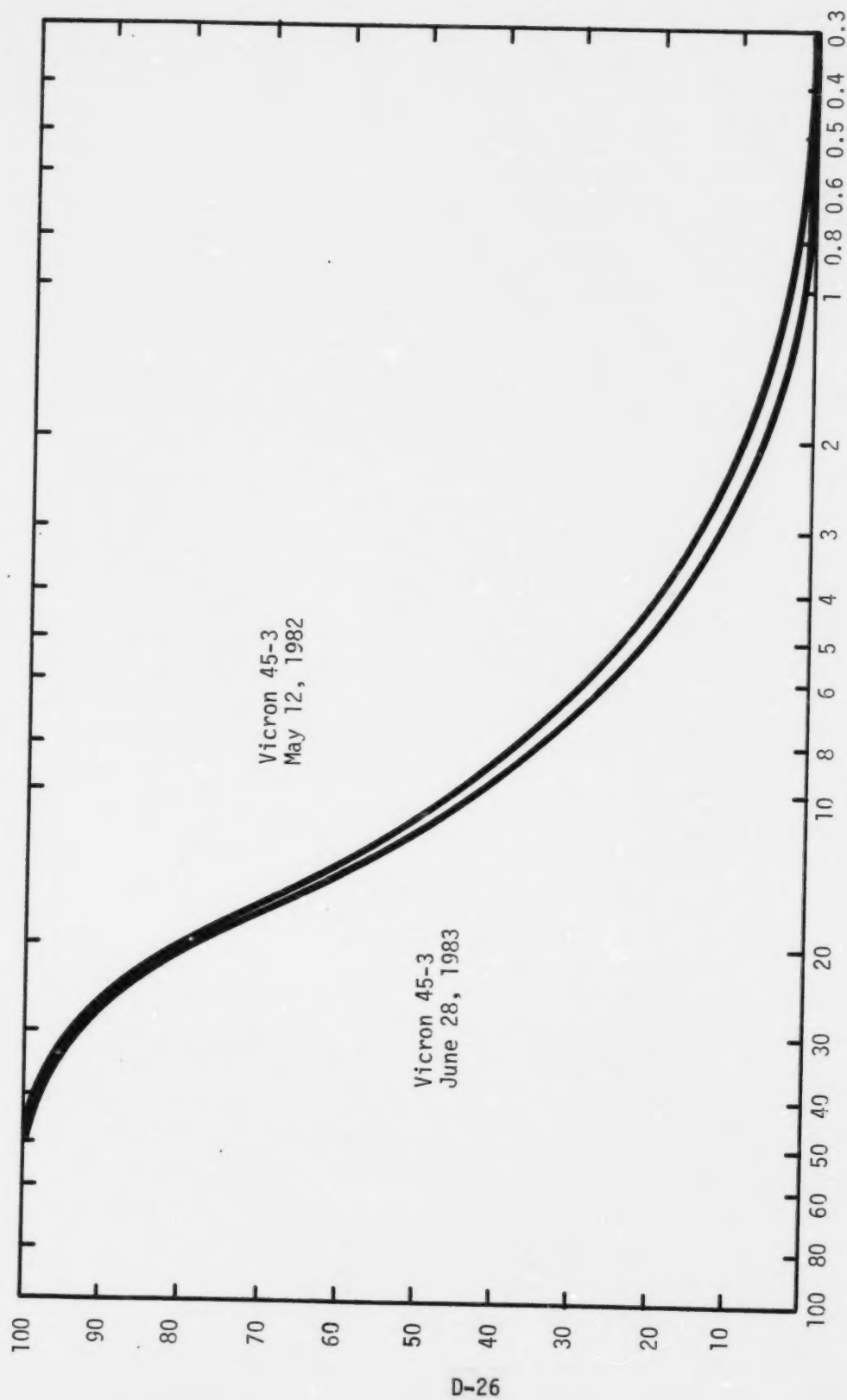


Figure D-9. Comparison of Vicron 45-3 Size Distribution

sorbent size distributions that were taken over one year apart. Figure D-8 shows that the dolomite had a mean size distribution that ranged from 36 to 40 microns and for the Vicron in Figure D-9, the variation was only about 1 m. Overall, the agreement was excellent.

Fuel analysis was performed at EER by methods described previously. Periodically, samples from the same coal bin were sent to an independent laboratory (Hazen Research). Tables D-8 and D-9 show comparisons of results obtained at EER vs the independent results for Illinois and Utah coals, respectively. Most of the elemental constituents were fairly close though some differences in heating value, moisture, and volatile matter was evident.

When new span gases are supplied to the facility, checks are performed to verify that actual concentrations match the label concentrations. Table D-10 illustrates the results for a high and low SO₂ span check. Label concentrations were reported as 2095 ppm and 520 ppm, respectively. Samples of both bottles were analyzed by titration and the results were reported as 2132 and 500 ppm. These values corresponded to differences of 2 and 4 percent from the suppliers concentrations.

In addition to the special systems checks mentioned above, spot checks by the EPA were done for the BSF analysis system for SO₂. These checks involved analysis of an unknown SO₂ sample by EER. The data was then reported to the EPA and compared to their results. Figure D 10 summarizes the results of the SO₂ spot checks. In all of the tests, agreement was favorable with a maximum percent difference of only 2.24 percent.

D.6 Data Reduction Validation and Reporting

After raw data has been collected from various experiments, a fair amount of data reduction is required before results can be reported in their final form. Equations used to calculate results for each of the measurements are discussed below. Many of the results are obtained directly from the measurements and thus will not require calculations.

TABLE D-8

ILLINOIS #6 LOT 1 COAL ANALYSIS
COMPARISON

Sample I.D. Analyzed Sy/Date	309/4-15-83 Hazen 5-5-83	BSF 4-15-83 EER 4-20-83
H ₂ O (ar)	7.79	4.70
Vol. M (ar)	33.89	41.93
Ash (ar)	10.42	9.62
Btu (ar)	10537	12017
C (def)	73.87	69.23
H (def)	5.	4.92
N (def)	1.27	1.47
S (dry)	3.37	3.50

TABLE D-9

UTAH COAL ANALYSIS COMPARISON

Sample I.D. Analyzed by/Date	308/4-15-83 Hazen 5-5-83	BSF 4-15-83 EER 4-20-83
H ₂ O (ar)	5.21	3.20
Vol. M. (ar)	39.14	42.78
Ash (ar)	8.00	7.26
Btu (ar)	11986	12699
C (daf)	78.26	74.27
H (daf)	5.62	5.54
N (daf)	1.48	1.60
S (daf)	0.76	0.91

TABLE D-10

LOG OF SPAN GAS CHECKS FOR SO₂

7B8C	HA1548 Dot	○ 520 PPM	B.S.F.	3	Aug. 500 PPM 4% DIF.	6-9-83
8B8C	HA1415 Dot	△ 2095 PPM	B.S.F.	1	Aug. 2132.0 PPM 2% DIF.	6-9-83

INTER-LABORATORY STUDY RESULTS			DATE PRINTED: 10/17/83
(AUGUST 1983)			
POLLUTANT - SO2			
645031			
MR. JIM REESE			
ENERGY & ENVIRONMENTAL RESEARCH			
18450N-SPACES			
IRVINE, CA 92714			
		UNITS - MILLIGRAMS PER DRY STA-CUBIC-METER	
SAMPLE NUMBER	RECORDED VALUE	PERCENT-DIFFERENCE	
3243	1450.0	1426.1	1.68
1157	400.0	396.6	.86
4166	625.0	633.0	-.79
6414	1380.0	1349.8	2.24
5238	602.0	594.8	1.21
1683.0			
1419.0			
R			
E			
P			
0-1000.0			
R			
E			
759.0			
420.0			
420.0	750.0	1080.0	1440.0
EPA RESULTS			
Y = 1.027X - 12.422			

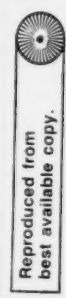


Figure D-10. Results of EPA spot SO₂ check.

1. Fuel and Particulate Analysis for Carbon, Hydrogen, Nitrogen

The data consist of millivolt responses from the analyzer. These millivolt responses are converted to micrograms using a graphical calibration curve generated with three standards. Weight percent is then calculated for each element, knowing the total sample weight as follows:

$$\text{element weight \%} = \frac{\text{element weight}}{\text{total sample weight}} \times 100$$

2. Fuel Size Distribution

Analytical data consist of weights of each size fraction which are converted to percent weight less than each size fraction from the equation:

$$\text{fraction weight \%} = \frac{\text{fraction weight}}{\text{total sample weight}} \times 100$$

Results are presented graphically plotting cumulative weight percent against particle size.

3. Fuel Flow Rate/Distribution

Fuel flow rate is obtained directly from the weigh feeder and is averaged over each test period.

4. Combustion Air Flow Rate/Distribution

Combustion air flow rate is read directly from rotameters or is calculated from pressure drop measured across laminar flow elements based on the equation:

$$Q = \frac{K(P)^{1/2}}{T}$$

where Q is the flow rate, K is a calibration factor determined for each flow element, P is the pressure drop measured across the element and T is the absolute temperature.

5. Combustion Air, Furnace Gas and Exhaust Gas Temperatures

Temperatures are measured by thermocouples and provide results in units of degrees centigrade which can then be converted to other temperature scales, as required.

6. Exhaust Gas Composition: NO, NO₂, O₂, CO, CO₂, SO₂

The above gas compositions are measured as chart divisions on a strip chart recorder. The measured divisions are converted to concentration (ppm or %) based on calculations with certified gases. Results are corrected to 0 percent oxygen concentration based on the measured oxygen concentrations.

7. Exhaust Gas Composition: SO₃

SO₃ results are determined from the titration of the collected SO₃ and the measured gas volume. Figure D-11 shows the form and equations used to calculate SO₃ results.

8. Sorbent Composition: Ca, Na, Mg, K

Sorbent composition is measured by atomic absorption with the results obtained as weight of each element based on a calibration curve from the analysis and calibration curves.

$\text{SO}_3 \text{ AS } \text{H}_2\text{SO}_4$ [illegible]

$$C_{H, 50\%} = \frac{10^{-5}}{V_m} = \frac{(1.081 \times 10^{-5})}{V_m} \frac{H}{(V - V_{LB})} \left(\frac{V}{50 \ln(V/V_{LB})} \right)$$

$$C_{H_2SO_4} \text{ ppm} = (C_{H_2SO_4} \text{ lb/ft}^3)(384.8 \text{ ft}^3/\text{mol})(10^6 \text{ lb/ft}^3) 10^6$$

Figure D-11. Summary of results SO_3 as H_2SO_4 .

12

Results are converted to weight percent based on this weight and the total sample weight.

9. Sorbent Flow Rate

Sorbent feed rate is determined by the set point of a volumetric feeder and the feeder calibration curve (mass vs. feeder setpoint). The feeder is calibrated daily with each sorbent.

10. Sorbent Size Distribution

Sorbent size distribution is plotted directly as size against cumulative weight percent by a Micromeritics Sedigraph Analyzer. Figure D-12 shows an example of a sorbent size distribution.

11. Sorbent Surface Area

Sorbent surface area is measured by a BET Quantasorb Analyzer. This analyzer measures the quantity of nitrogen condensed on the sample surface by thermal conductivity based on calibration standards. This quantity of nitrogen is converted to surface area based on a monolayer of nitrogen condensed on the sample and the known volume of nitrogen molecules following the instrument manufacturer's instructions.

D.7 Basic SO₂ Capture Experiments

The procedure for a typical SO₂ capture experiment has been standardized and is described in detail below.

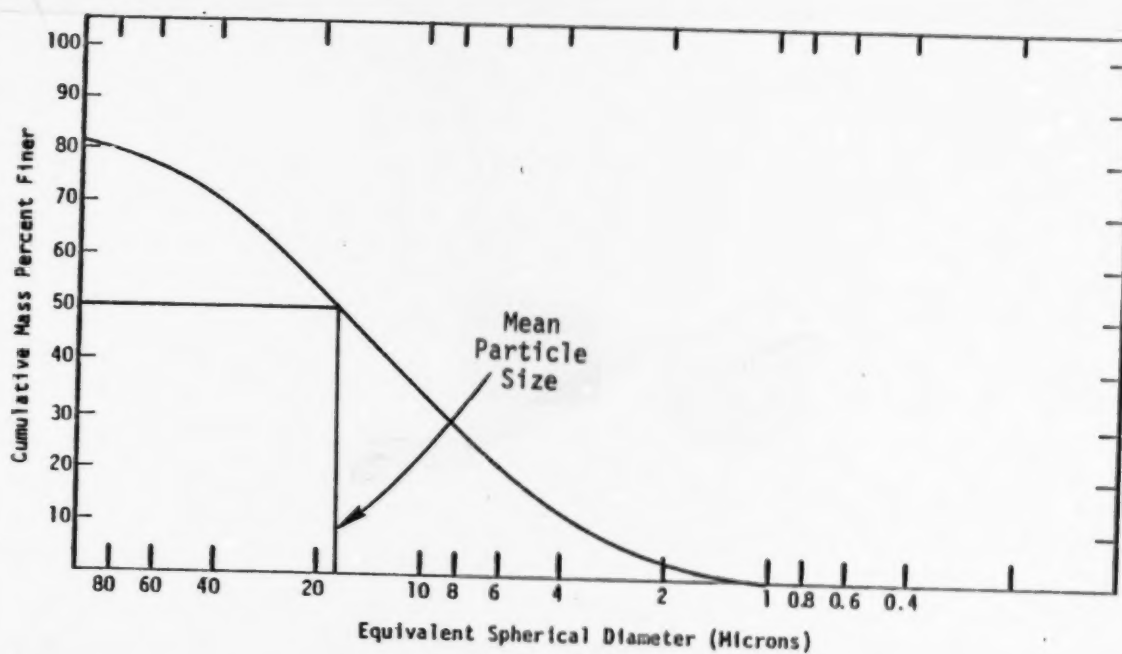


Figure D-12. Example of sorbent particle size distribution.

For a natural gas experiment, the baseline conditions are checked initially which includes correct air and fuel flow rates, exhaust O_2 , CO , CO_2 , NO_x , furnace temperatures, as well as burner and overall stoichiometries. After these considerations produce stable traces, the H_2S flow rate is adjusted to give the desired SO_2 concentration in the flue gas. SO_2 concentrations are checked at all three ports three different times to ensure that SO_2 concentration does not change in the flue gas throughout the furnace.

After the SO_2 level is verified, the sorbent injection system is started and SO_2 is measured at port 3 until steady. At this point, measurements are taken at ports 1, 2 and 3 in succession. A measurement is then repeated at port 2 and if there is no change in the SO_2 level, the sorbent is turned off. The sample is then switched back to port 3 until the SO_2 level returns to the baseline condition. The maximum time that the sorbent is on during any single experiment is 20 minutes. For coal, the procedure is identical except that the coal produces its own SO_2 and the H_2S system is not used.

Throughout the course of this testing program, many points were repeated as a means for checking data reproducibility. The following figures show data taken as much as a year apart for various firing conditions. Figure D-13 shows the repeatability for gas/ H_2S flames with Vicron 45-3 injected at the fuel. Initial SO_2 ranged from 1000-1100 ppm as measured at port 3. Reproducibility for this range was excellent as indicated by the minimal scatter. Figure D-14 shows similar data for a range of SO_2 from 1550-1900 ppm. Some scatter in this data was apparent though the general trend exhibited was consistent.

Figure D-15 illustrates the reproducibility of coal with dolomite sorbent injected with the fuel for runs taken over the course of a year and a half. For this set of experiments, the agreement was very good with very little scatter.

SO₂ CAPTURE IN NATURAL - H₂S FLAME
 SORBENT VICRON 45-3 AT FUEL
 SR_p = .11 SR_B = .6 SR_T = 1.18
 SO₂ 1000 - 1100 PPM AT PORT #3
 UNCOOLED, NO AIR HEAT

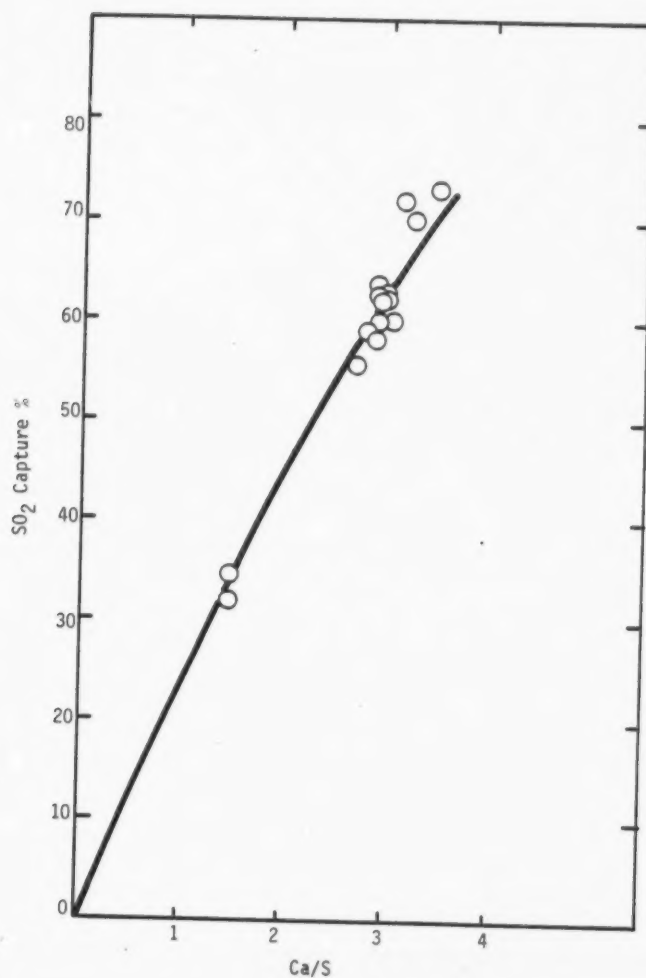


Figure D-13. Repeatability of Gas/Vicron 45-3 data for 1000 - 1100 ppm SO₂.

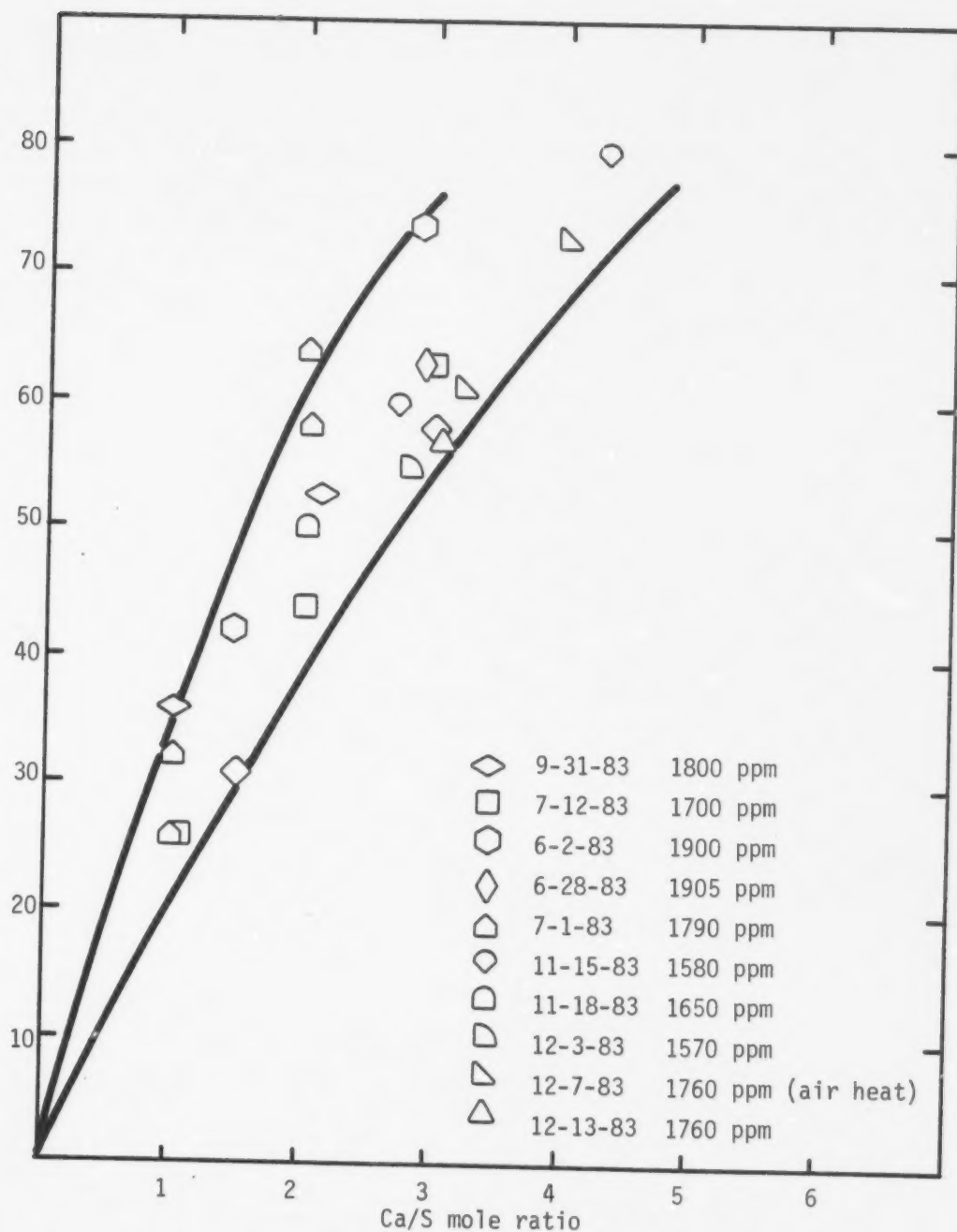


Figure D-14. Repeatability of Gas/Vicron 45-3 data for 1550-1900 ppm SO_2 .

DOLOMITE (REGULAR)

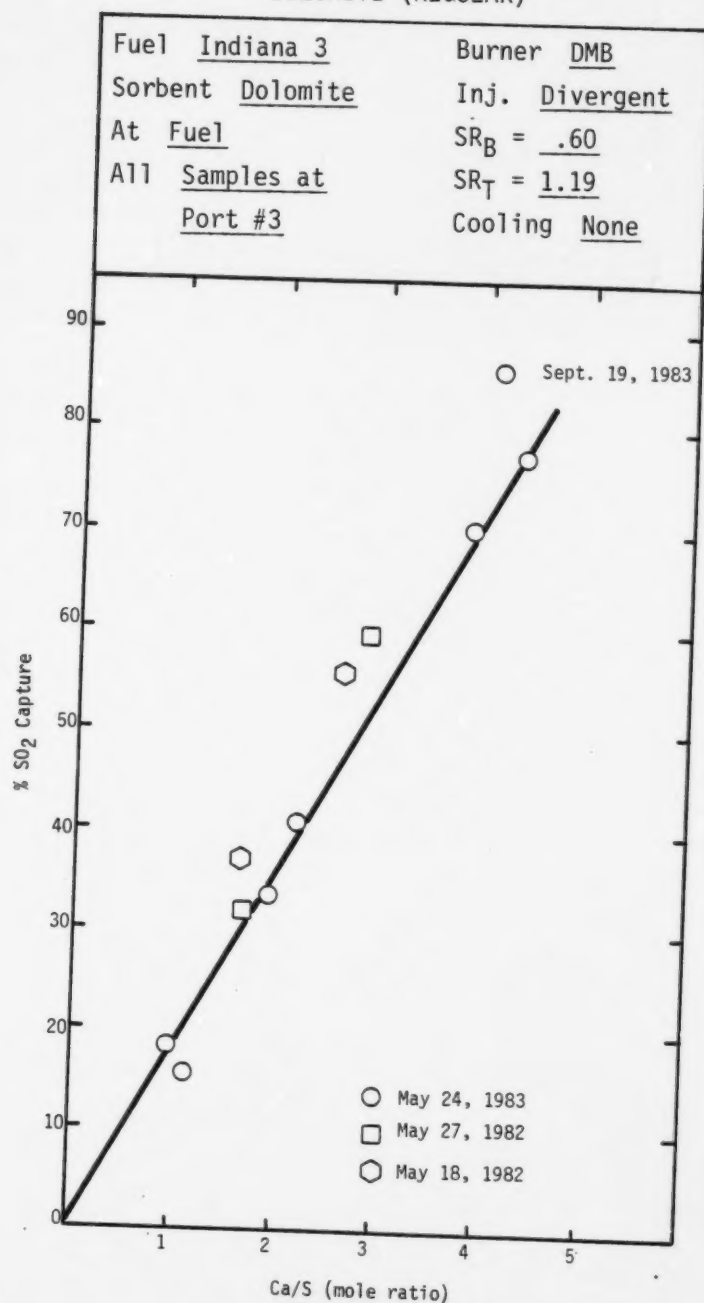


Figure D-15. Repeatability of coal with Dolomite.

APPENDIX E--SULFUR CAPTURE CURVES

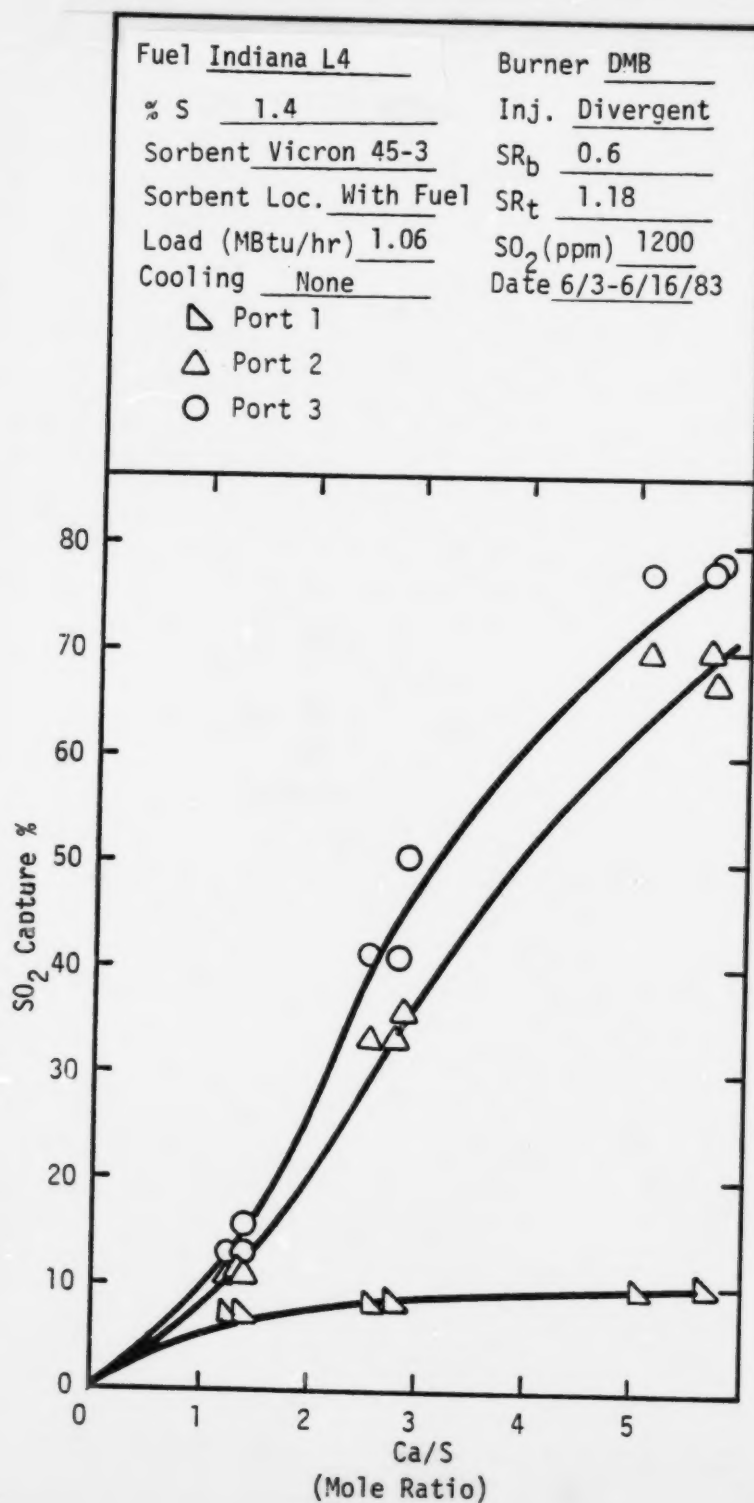


Figure E-1. Sulfur capture through BSF Indiana (lot 4) coal with Vicron 45-3.

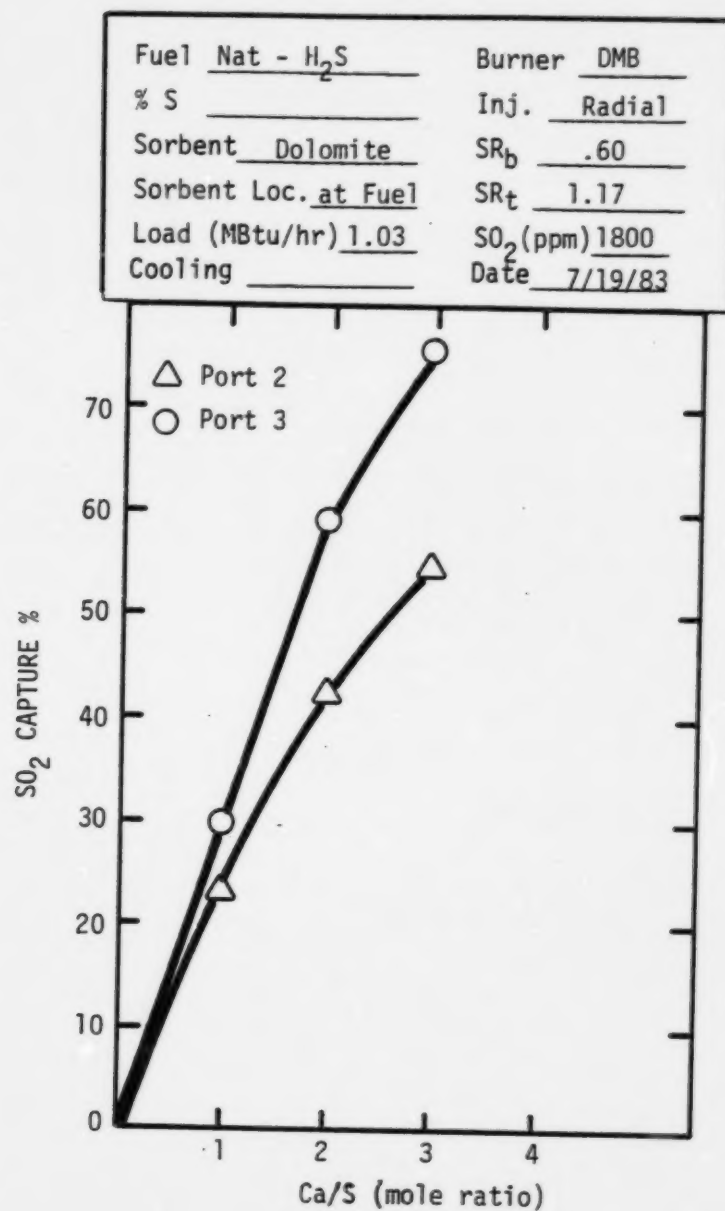


Figure E-2. Sulfur capture through BSF natural gas/H₂S with dolomite.

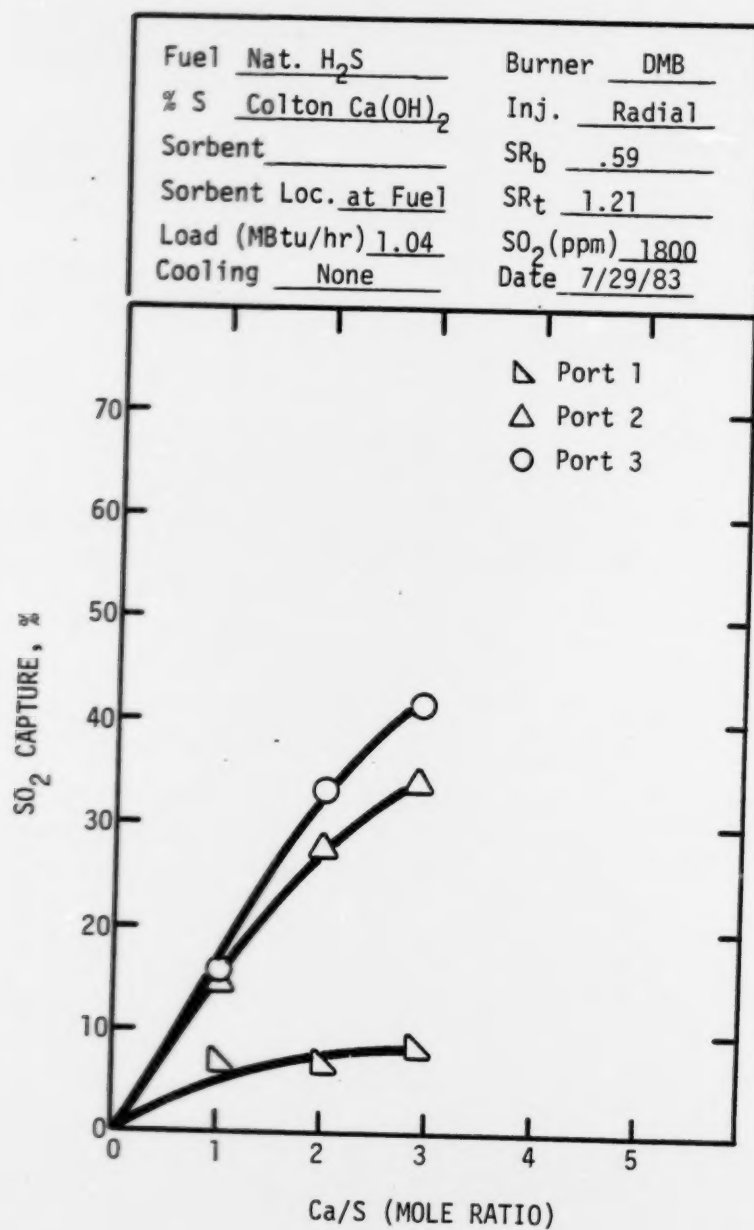


Figure E-3. Sulfur capture through BSF, natural gas/H₂S with Ca(OH)₂ (Colton).

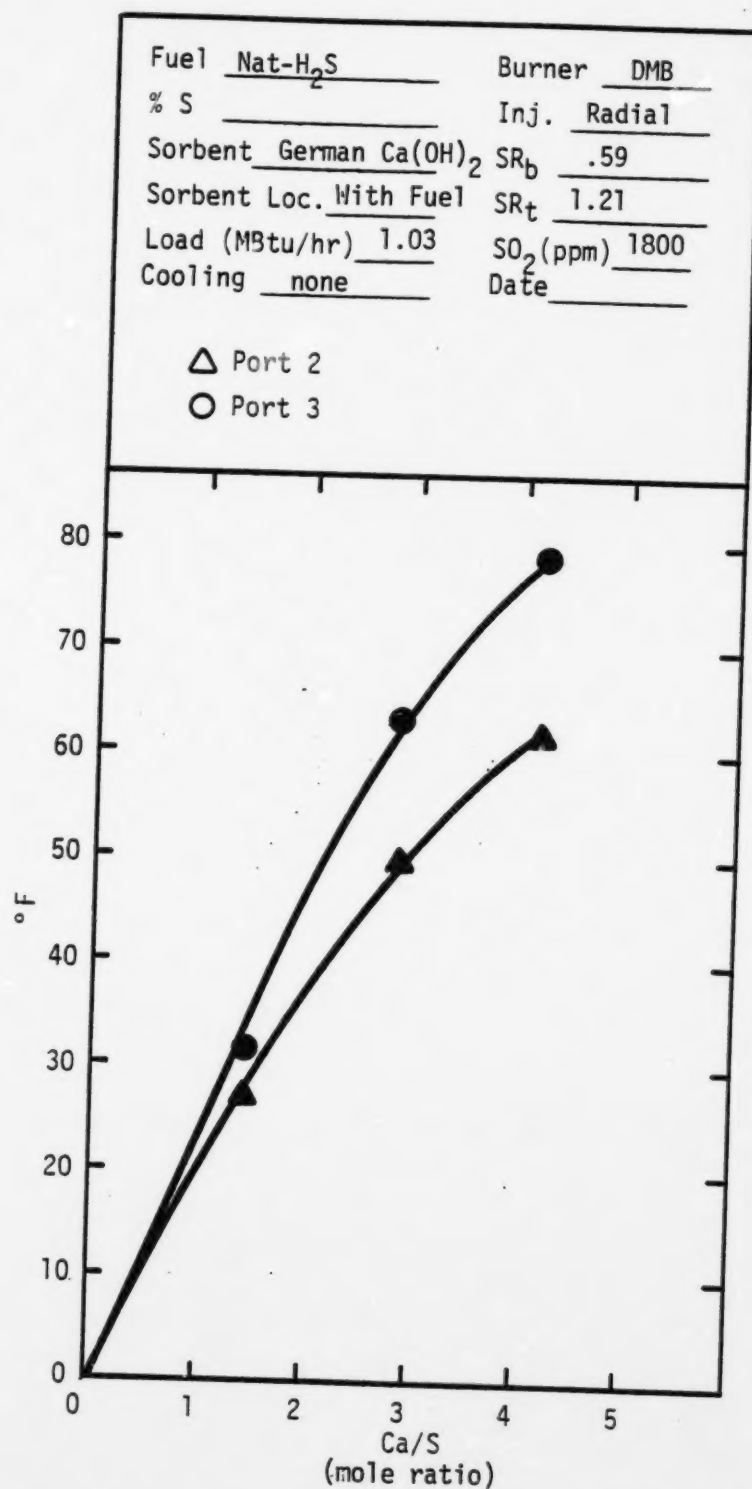


Figure E-4. Sulfur capture through BSF natural gas with Steinmuller hydroxide.

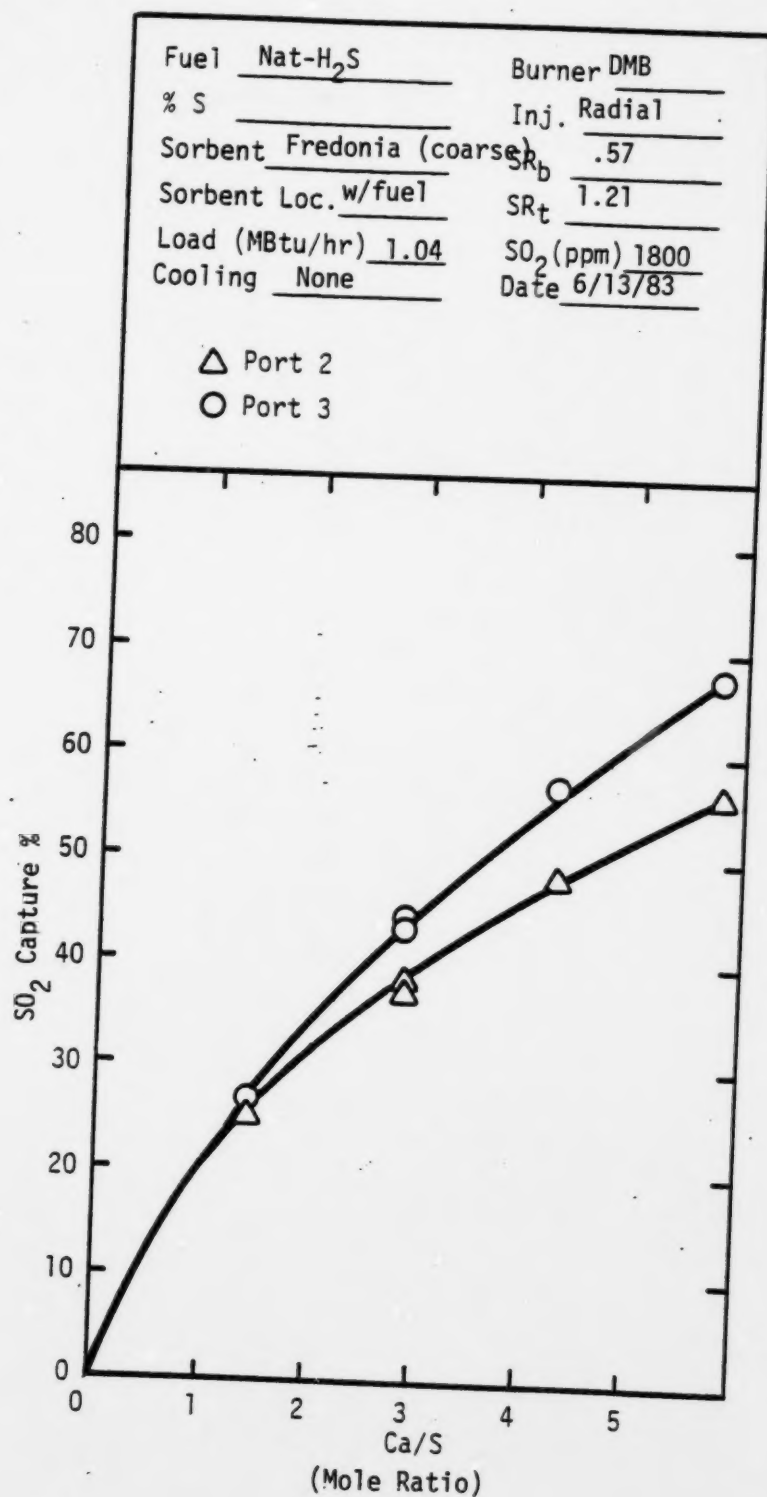


Figure E-5. Sulfur capture through BSF with natural gas, coarse Fredonia.

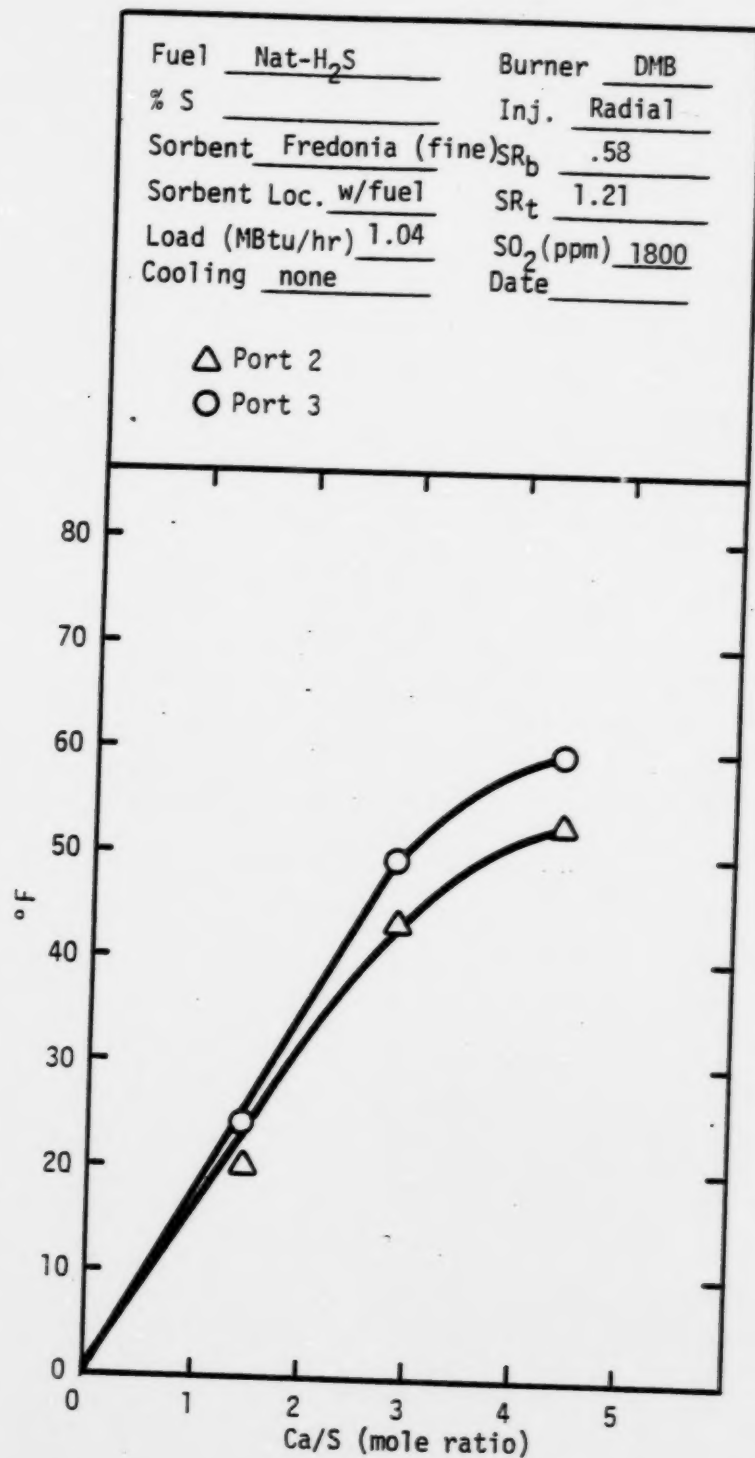


Figure E-6. Sulfur capture through BSF natural gas with fine Fredonia.

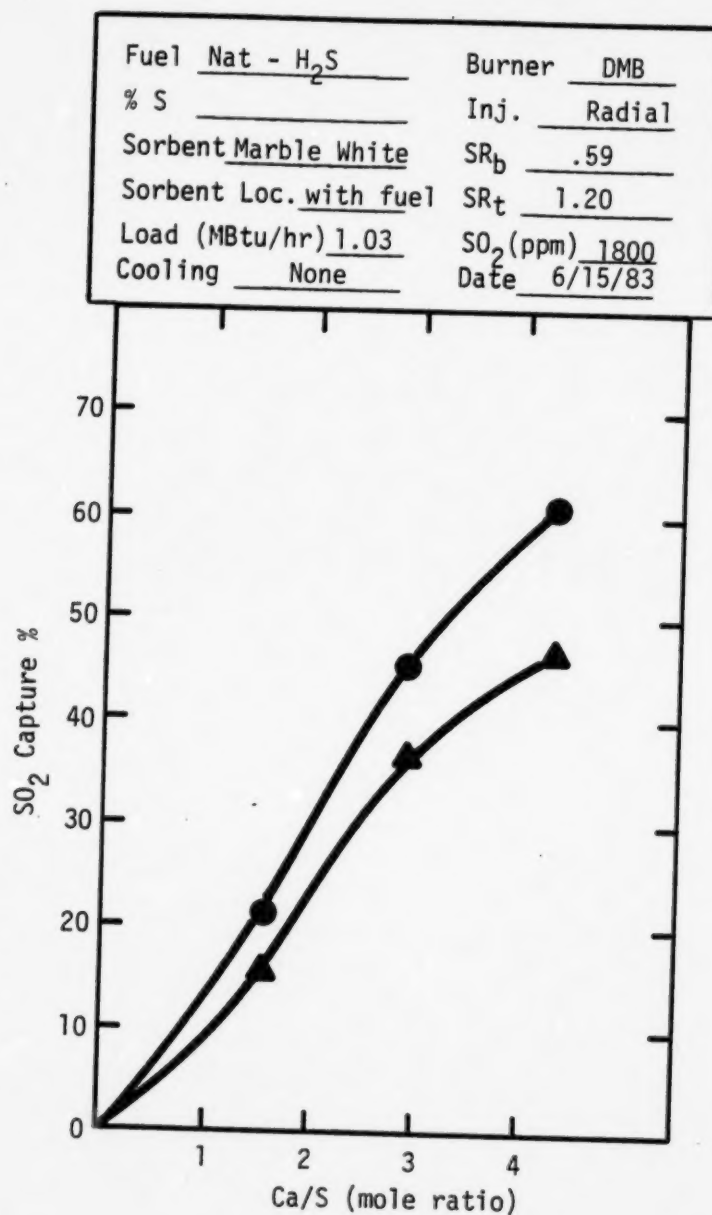


Figure E-7. Sulfur capture through BSF, natural gas / H₂S with marble white 125.

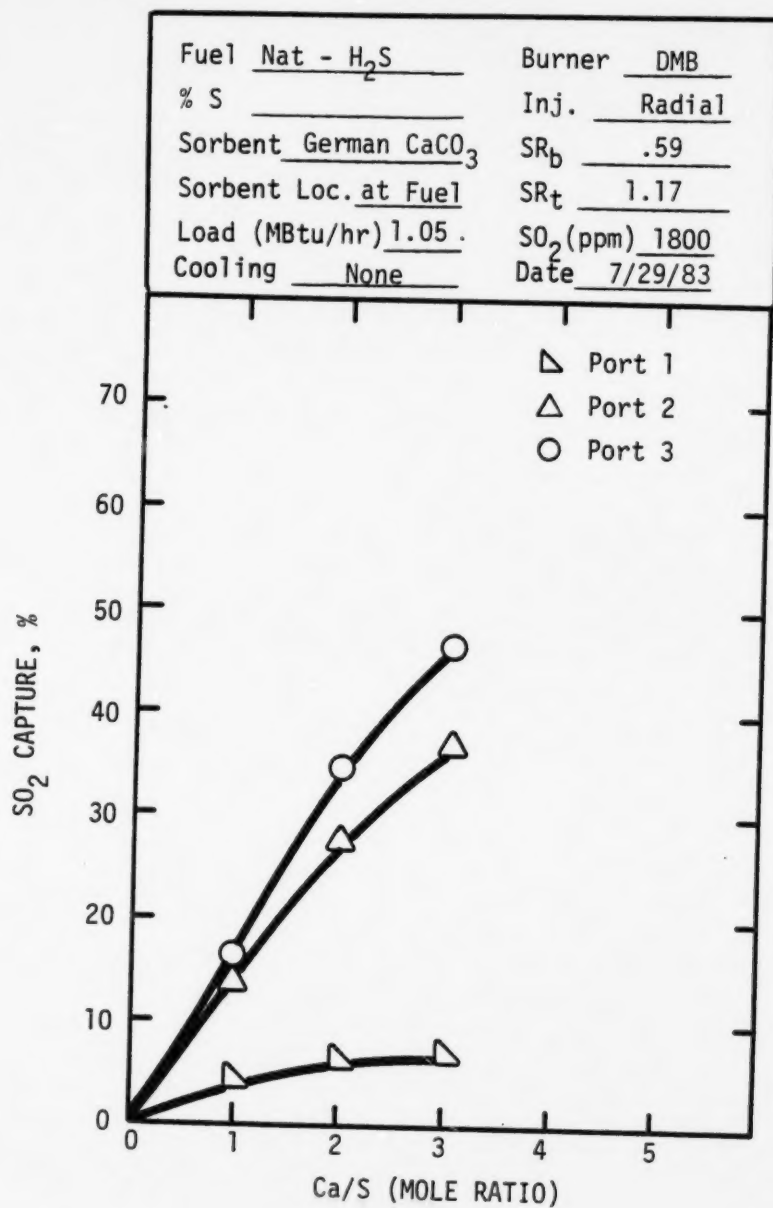


Figure E-8. Sulfur capture through BSF, natural gas/H₂S with German (Steinmüller) CaCO₃

Fuel	Nat-H ₂ S	Burner	DMB
% S		Inj.	Radial
Sorbent	Vicron 45-3	SR _b	.73
Sorbent Loc.	w/fuel	SR _t	1.21
Load (MBtu/hr)	1.80	SO ₂ (ppm)	1800
Cooling	none	Date	6/2/83

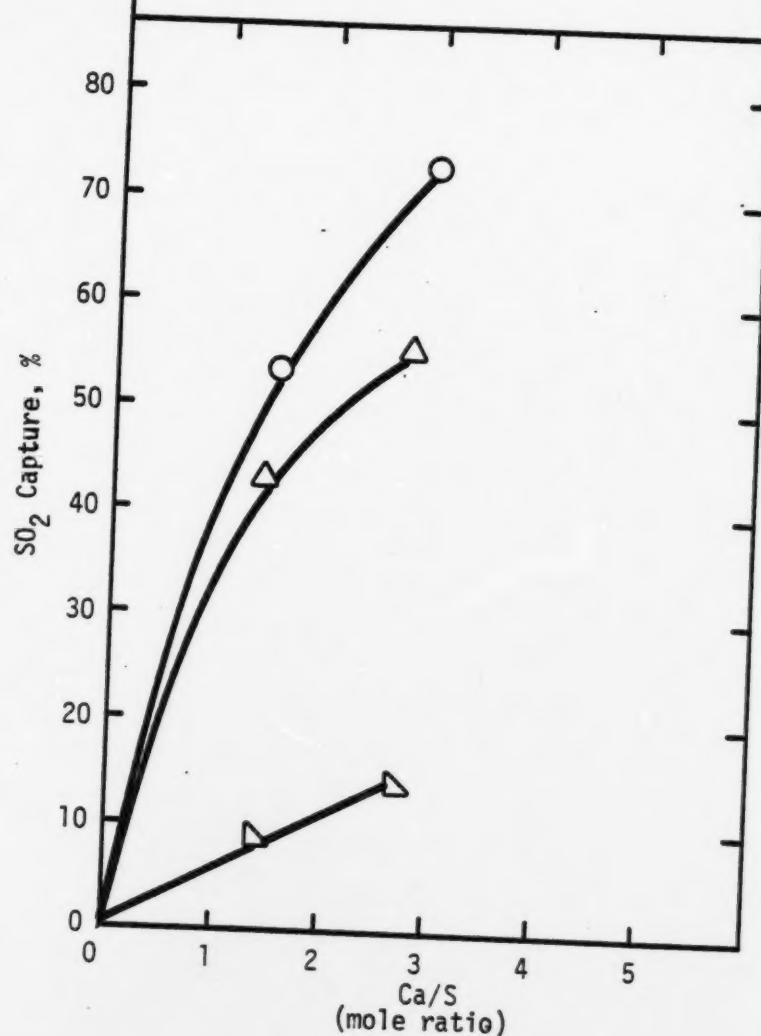


Figure E-9. Sulfur capture at high load (1.8 MBtu/hr) BSF, natural gas + H₂S with Vicron 45-3.

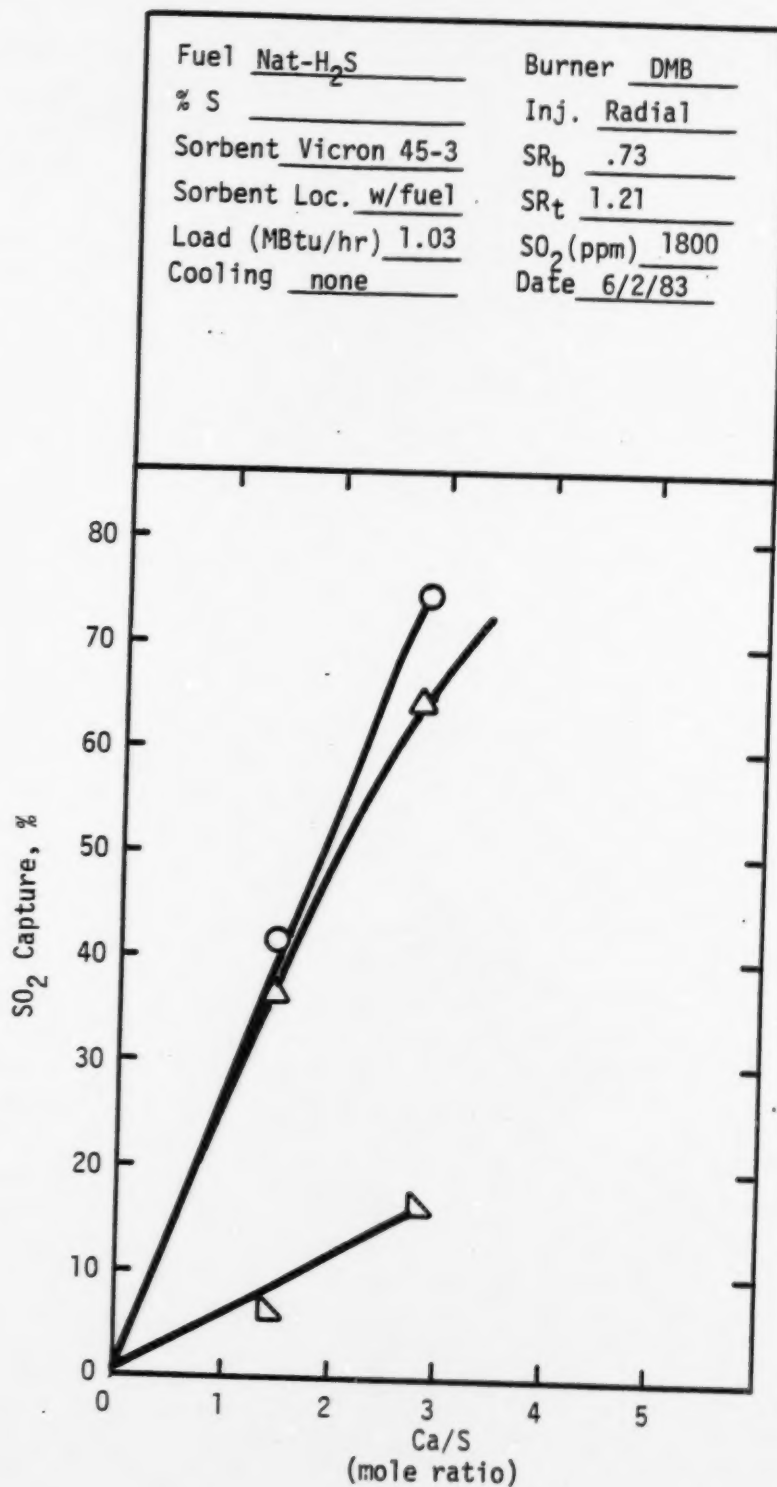


Figure E-10. Sulfur capture at baseload (1.0 MBtu/hr) BSF, natural gas + H₂S with Vicron 45-3.

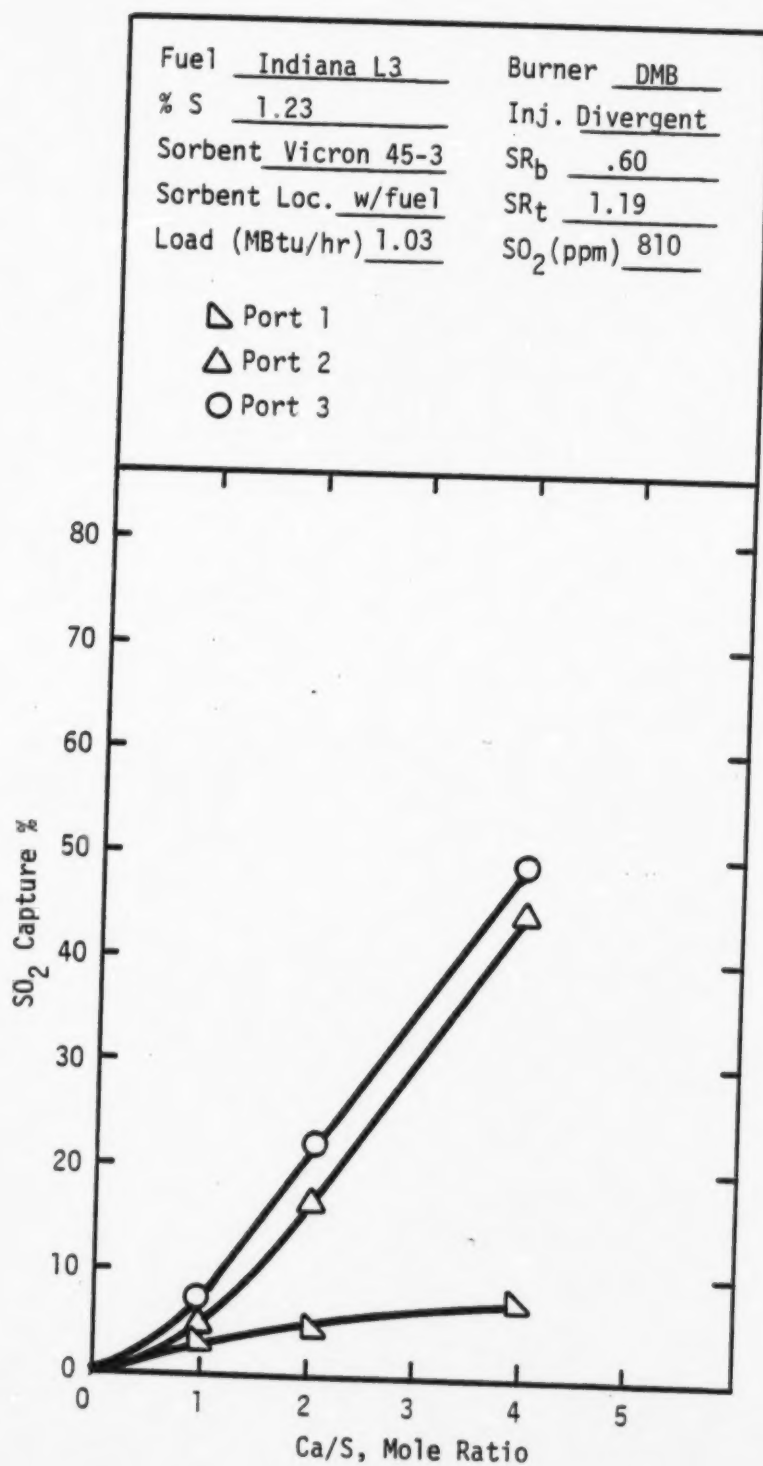


Figure E-11. Sulfur capture through BSF, Vicron 45-3 and Indiana L3 coal.

E-11

Fuel	Indiana L3	Burner	DMB
% S	1.14	Inj.	Divergent
Sorbent	Vicron 45-3 + 5% K_2CO_3	SR_b	.60
Sorbent Loc.w/fuel		SR_t	1.19
Load (MBtu/hr)	1.04	SO_2 (ppm)	830

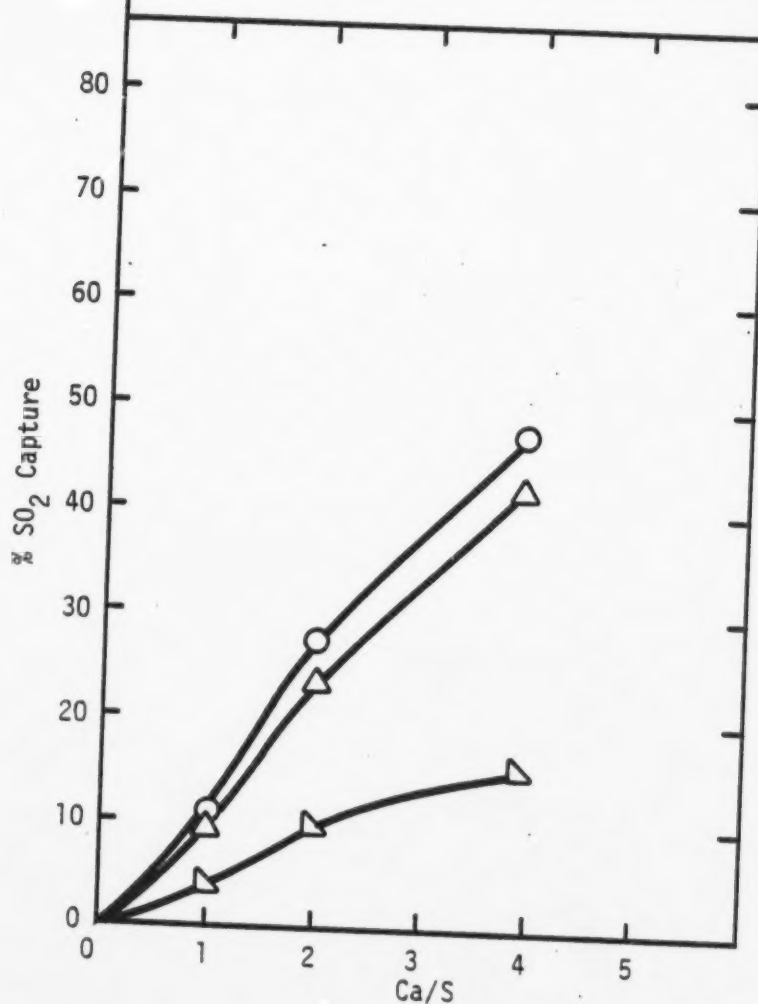


Figure E-12. Sulfur capture through BSF - Indiana (lot 3) coal with Vicron 45-3/ K_2CO_3 (5%) mixture.

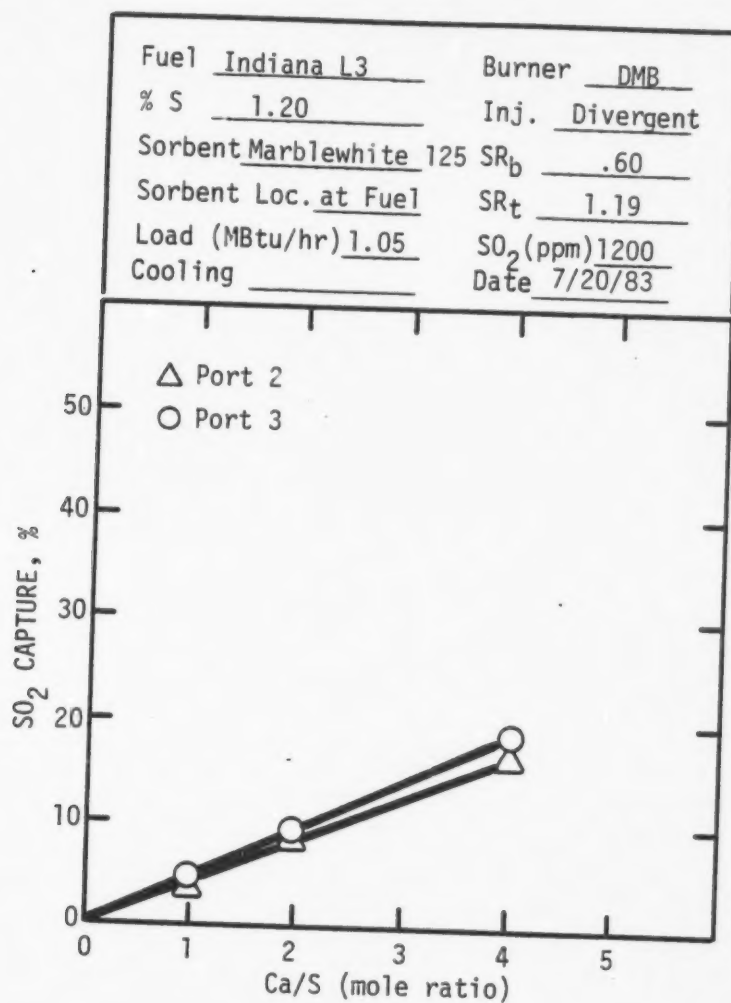


Figure E-13. Sulfur capture through BSF, Indiana L3 coal, with marblewhite 125.

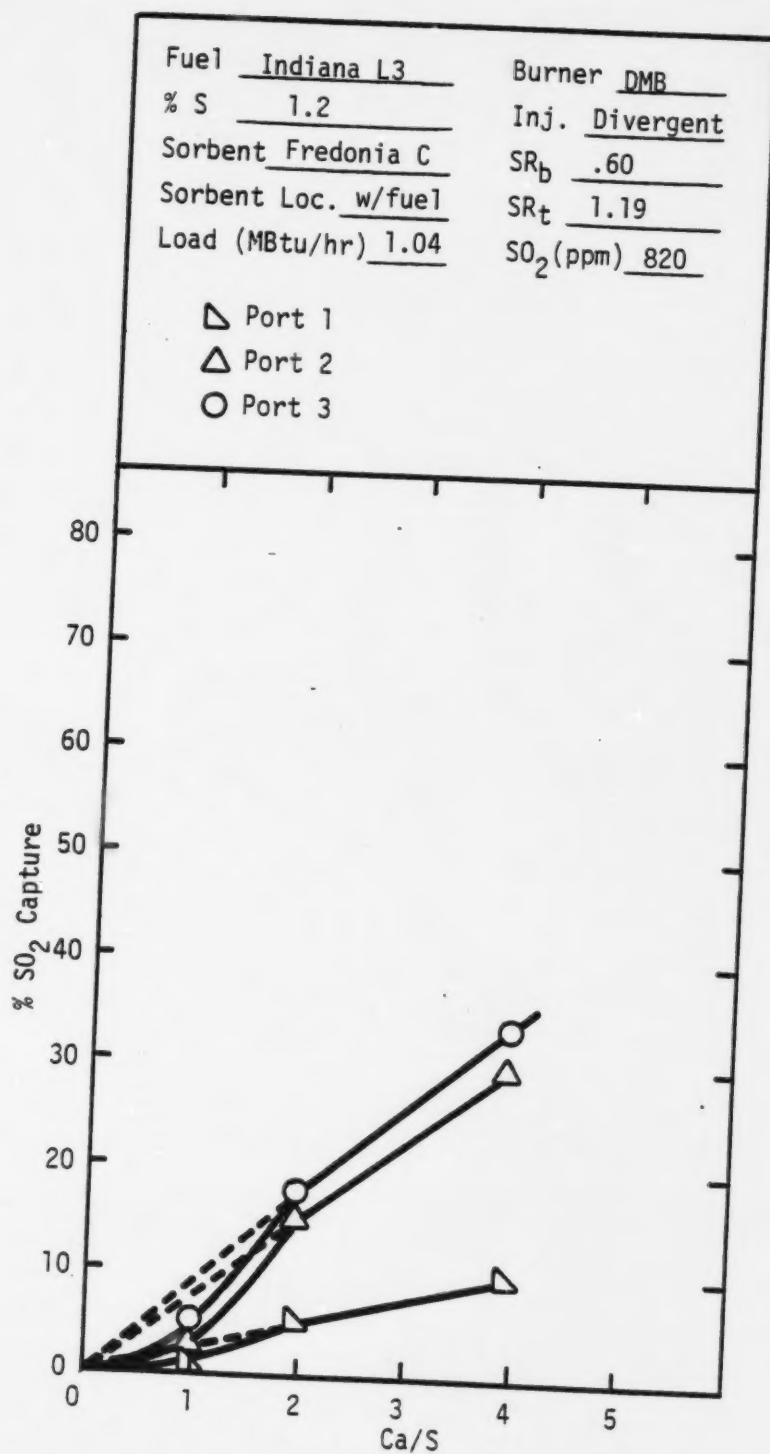


Figure E-14. Sulfur capture through BSF - Indiana (lot 3) coal with Fredonia C.

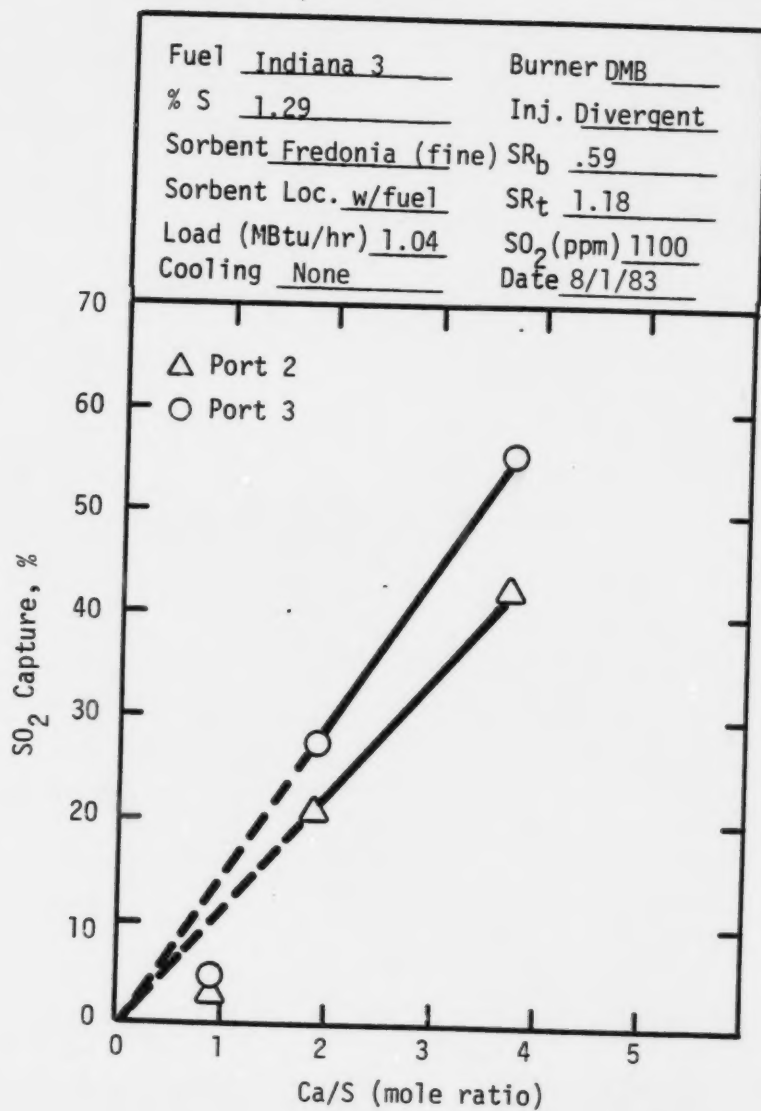


Figure E-15. Sulfur capture through BSF, Indiana L3 coal with fine Fredonia.

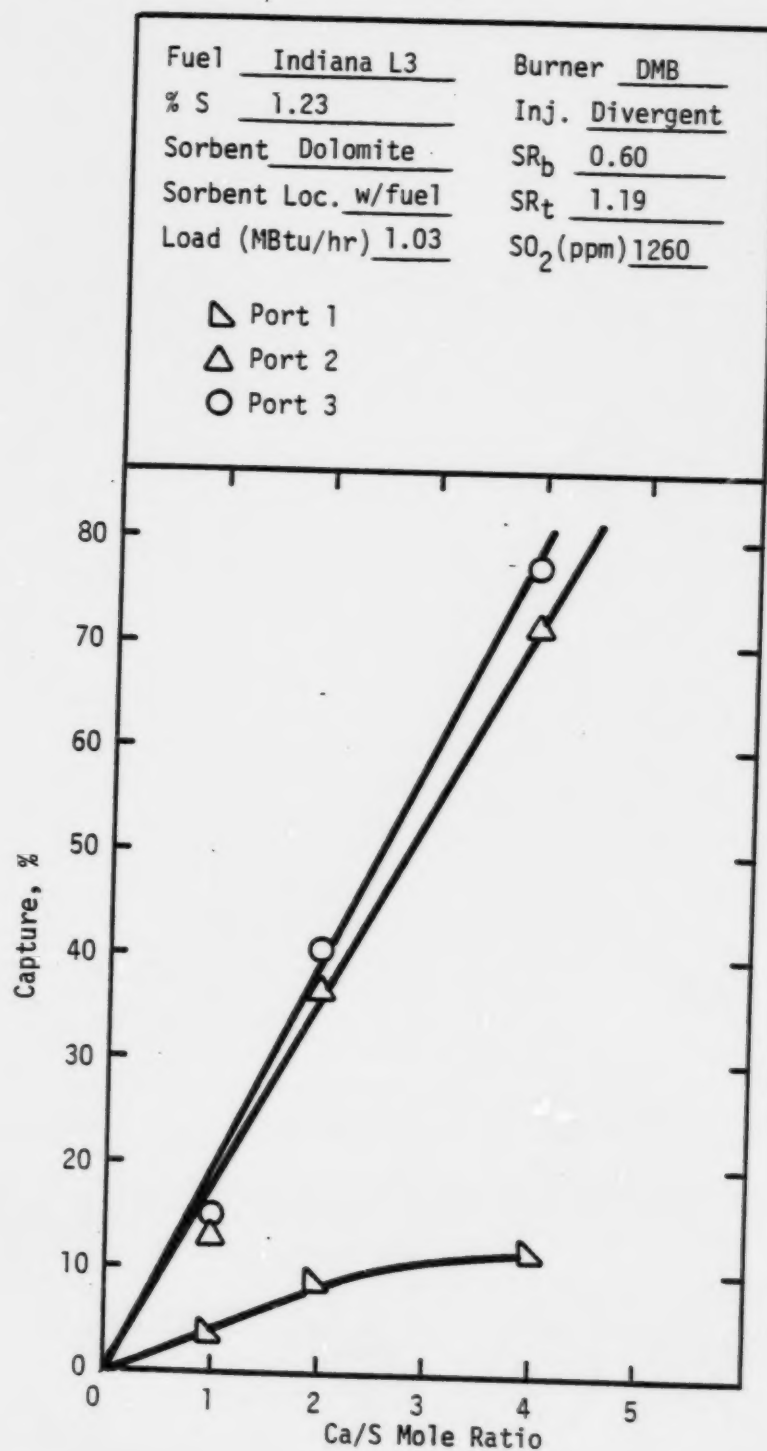


Figure E-16. Sulfur Capture through BSF - Indiana (lot 3) coal with dolomite.

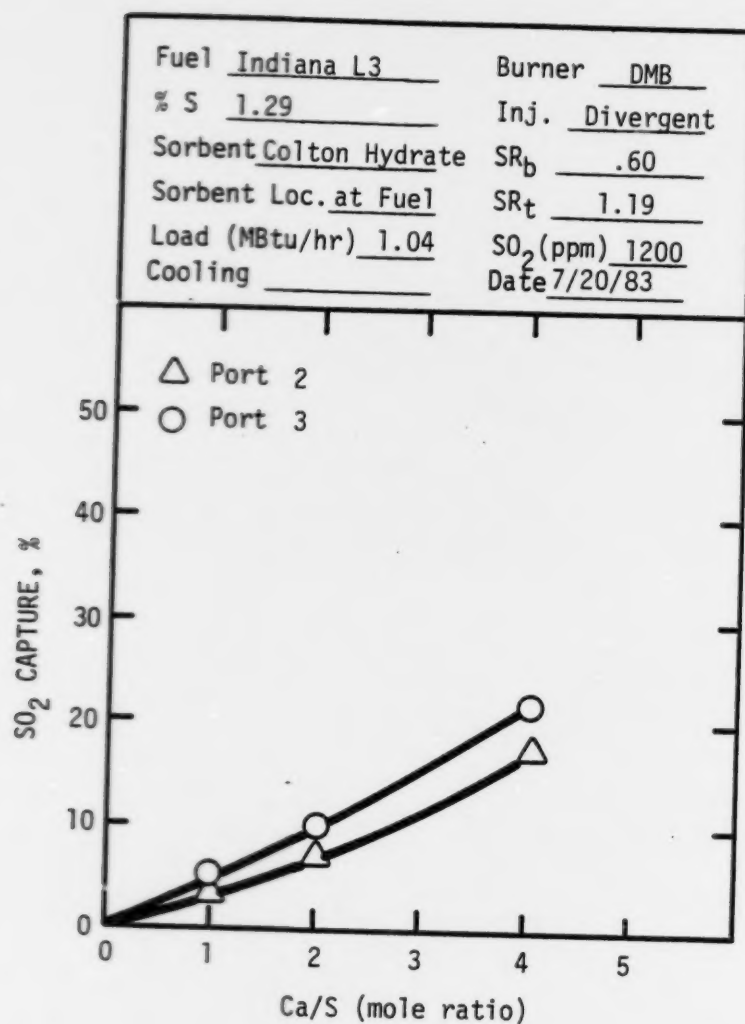


Figure E-17. Sulfur capture through BSF, Indiana L3 coal with $\text{Ca}(\text{OH})_2$ (Colton).

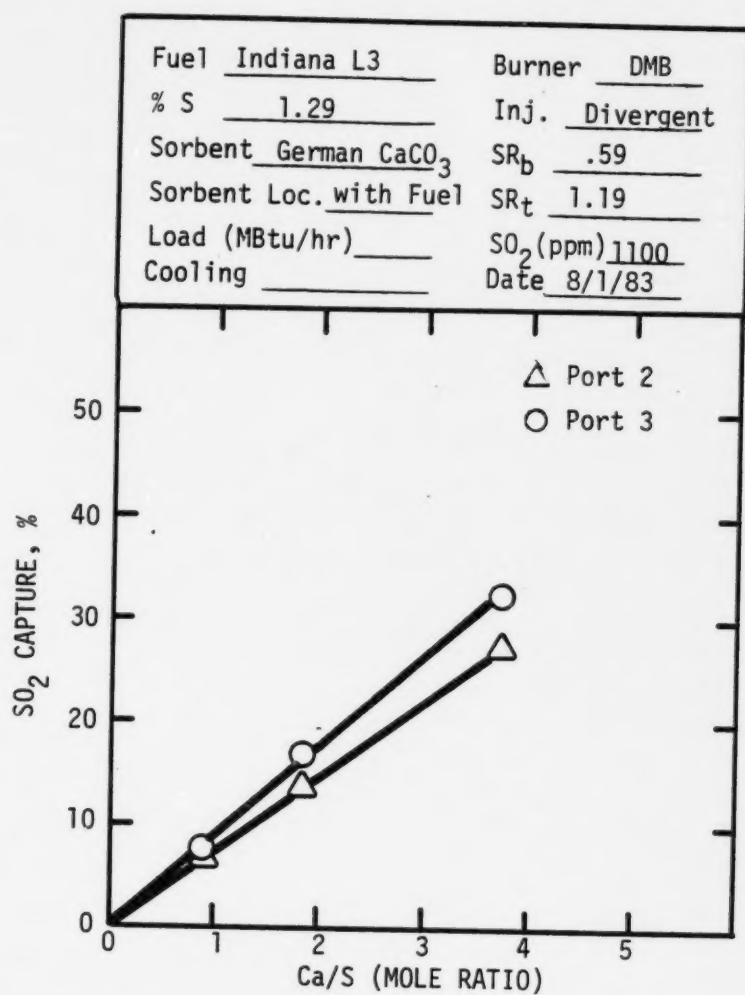


Figure E-18. Sulfur capture through BSF, Indiana L3 coal with German (Steinmuller) CaCO_3 .

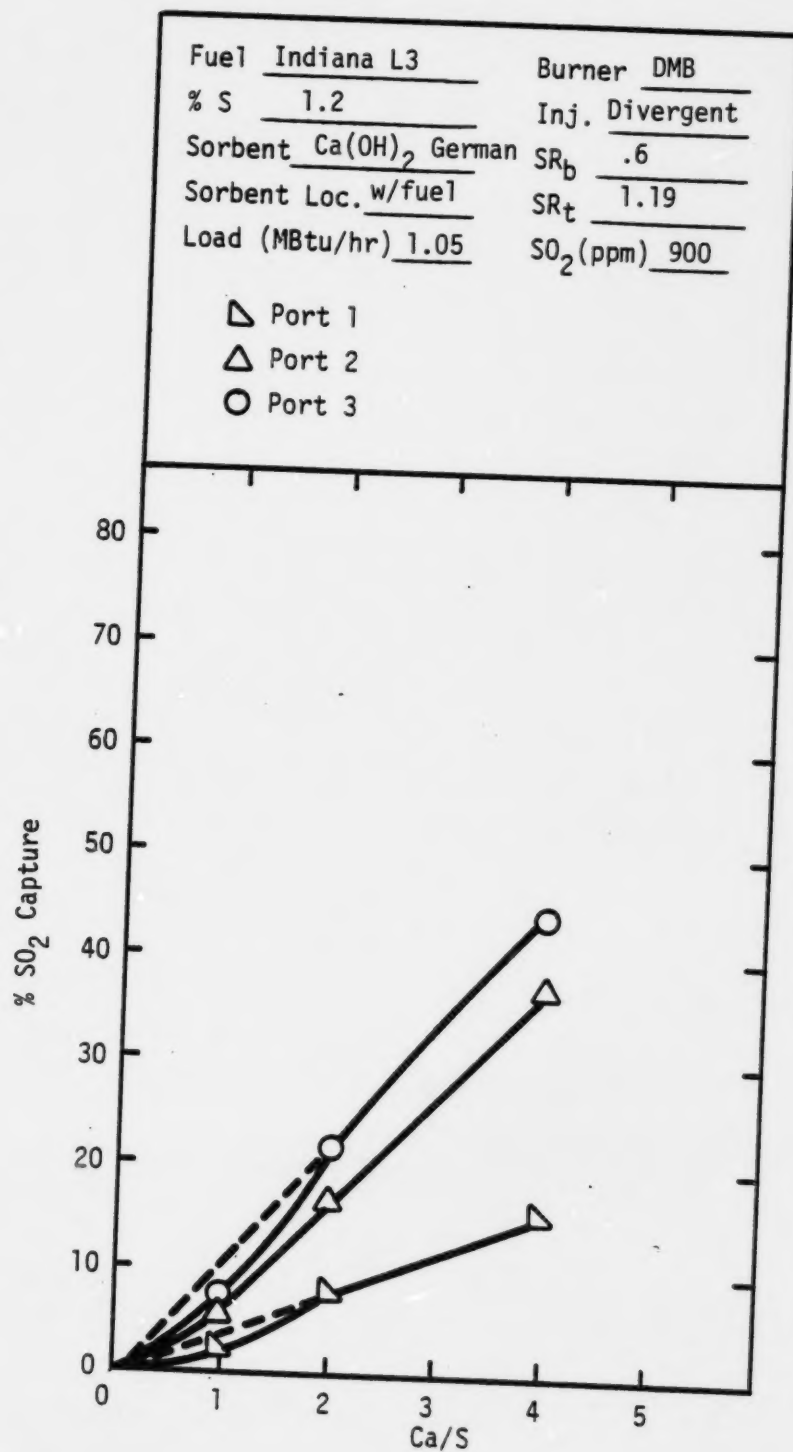


Figure E-19. Sulfur capture through BSF - Indiana (lot 3) coal with Vicron 45-3 +5% K₂CO₃.

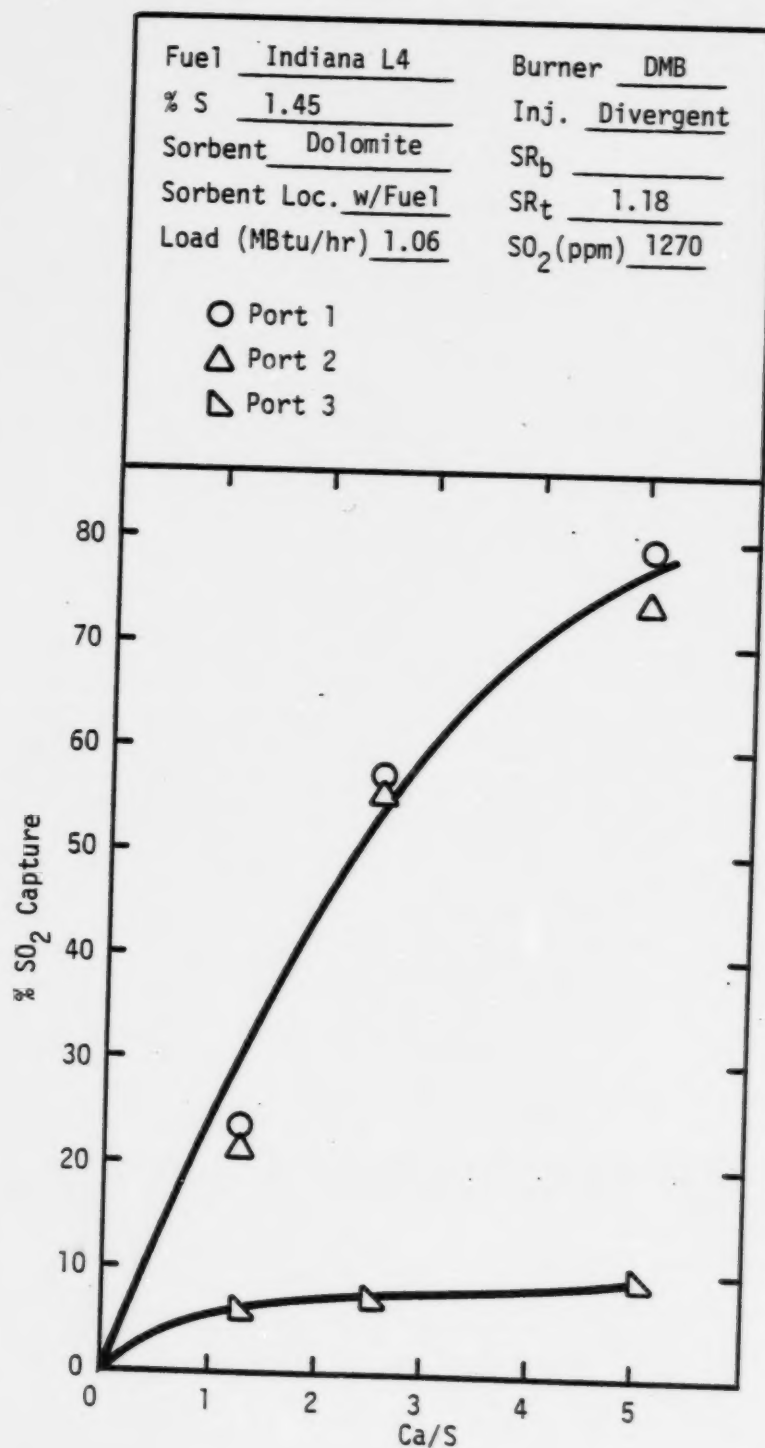


Figure E-20. Sulfur capture through BSF - Indiana (lot 4) coal with Dolomite.

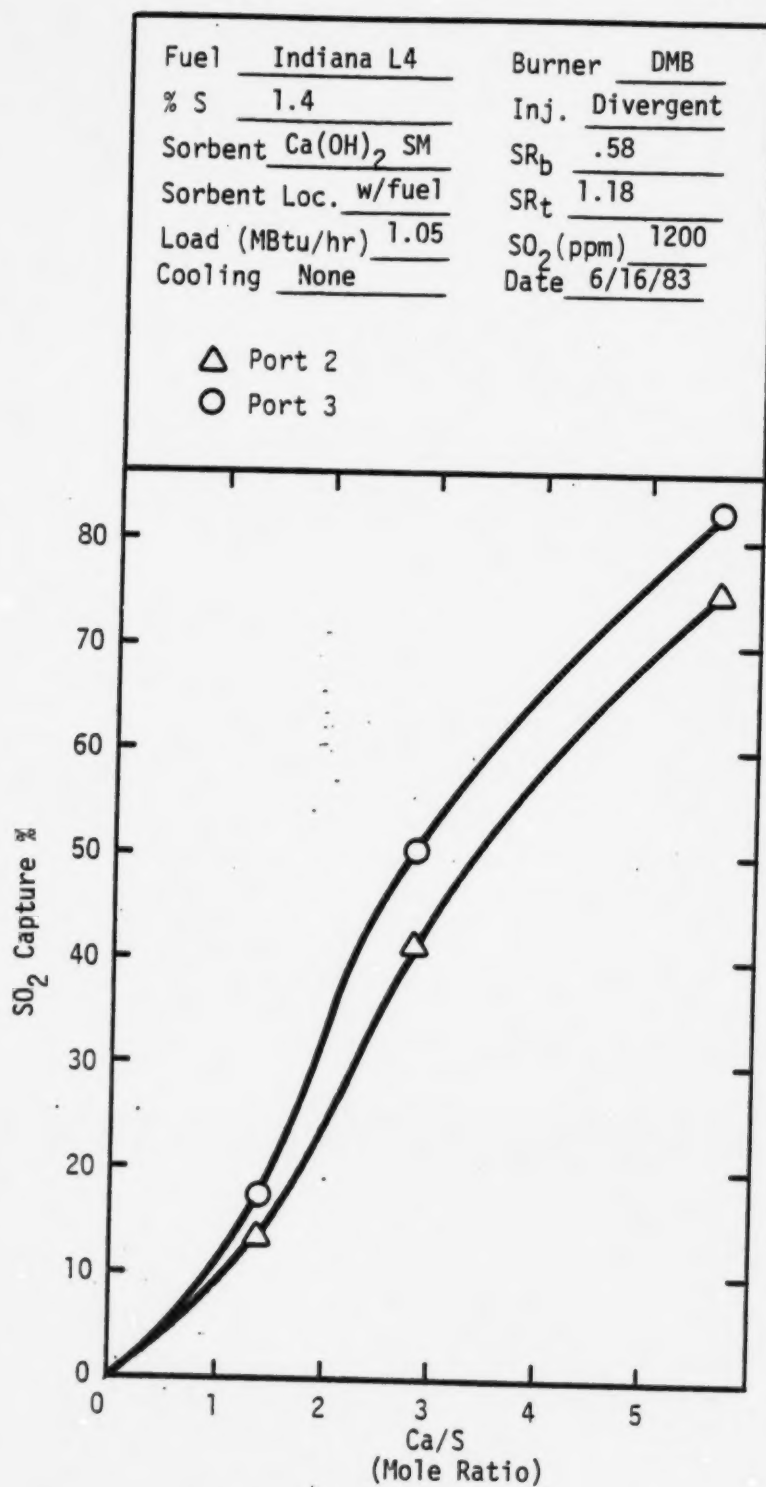


Figure E-21. Sulfur capture through BSF, Indiana (L4) coal with Steinmuller Ca(OH)₂.

Fuel	Indiana L4	Burner	DMB
% S	1.4	Inj.	Divergent
Sorbent	Fredonia (coarse)	SR _b	.60
Sorbent Loc. w/fuel		SR _t	1.18
Load (MBtu/hr)	1.05	SO ₂ (ppm)	1200
Cooling	None	Date	6/6/83

▴ Port 1
 △ Port 2
 ○ Port 3

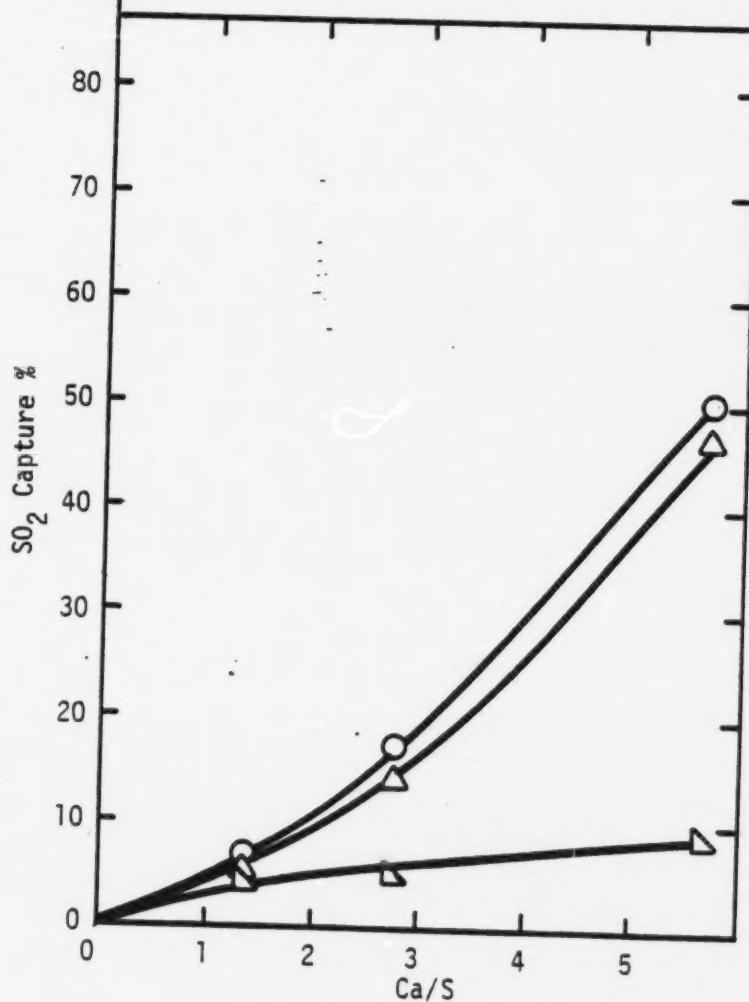


Figure E-22. Sulfur capture through BSF, Indiana coal (L4) with coarse Fredonia.

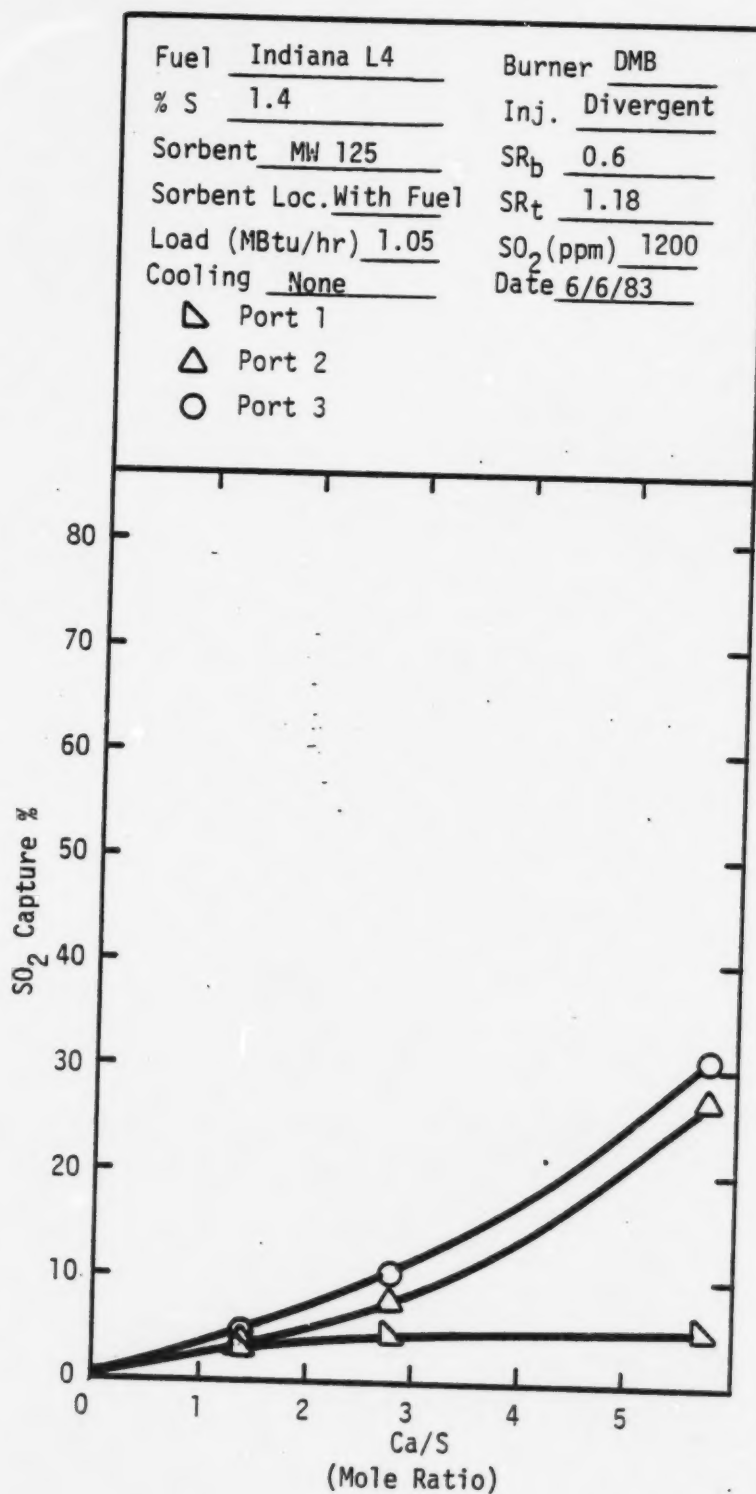


Figure E-23. Sulfur capture through BSF Indiana coal (L4) with Marble White 125.

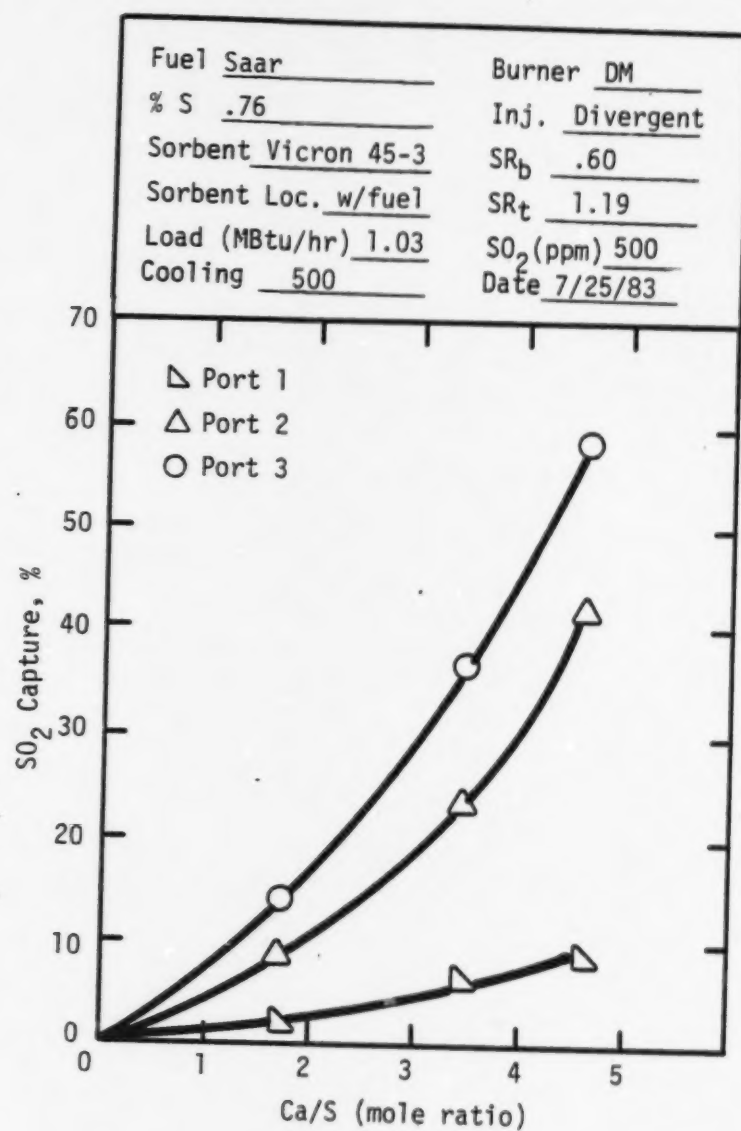


Figure E-24. Sulfur capture through BSF, Saar coal with Vicron 45-3.

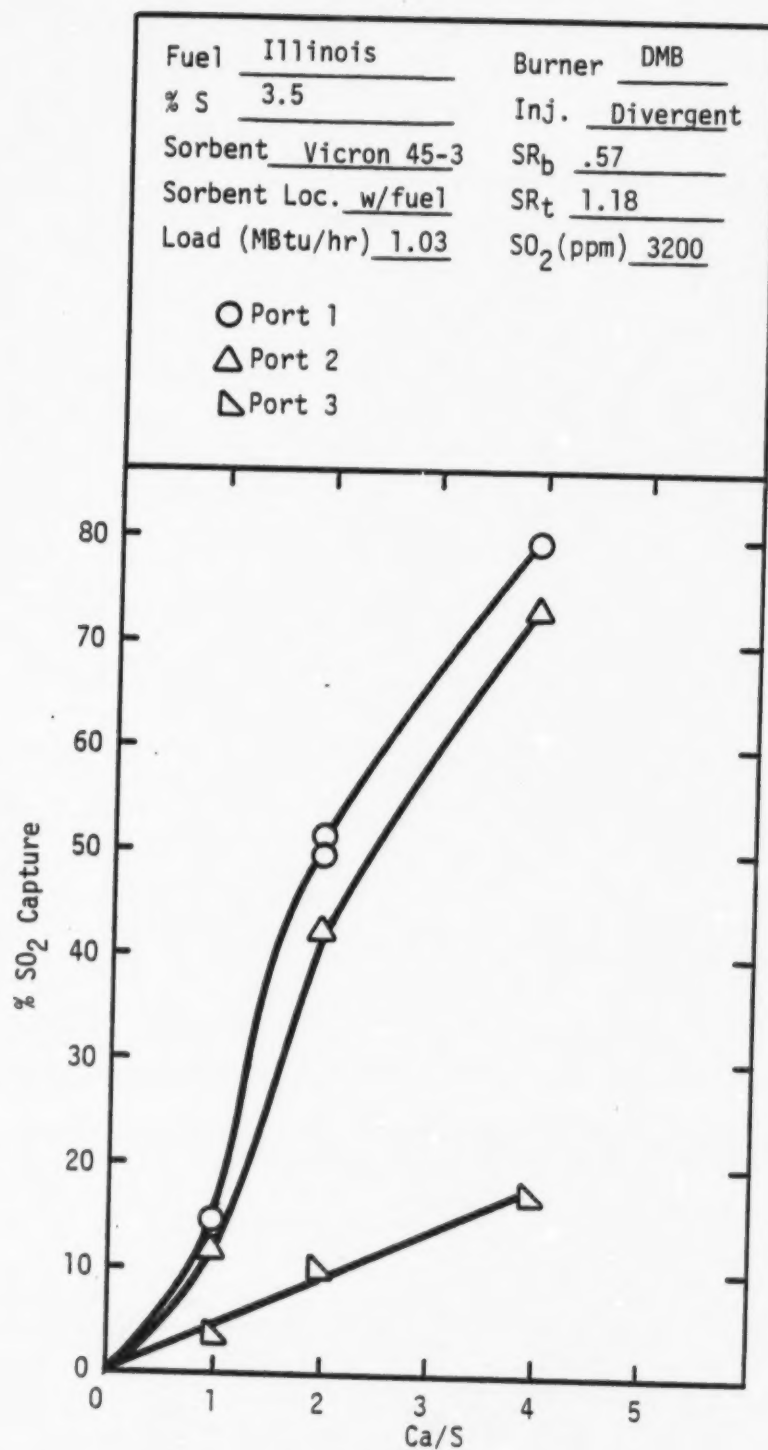


Figure E-25. Sulfur capture through BSF, Illinois coal w/Vicron 45-3.

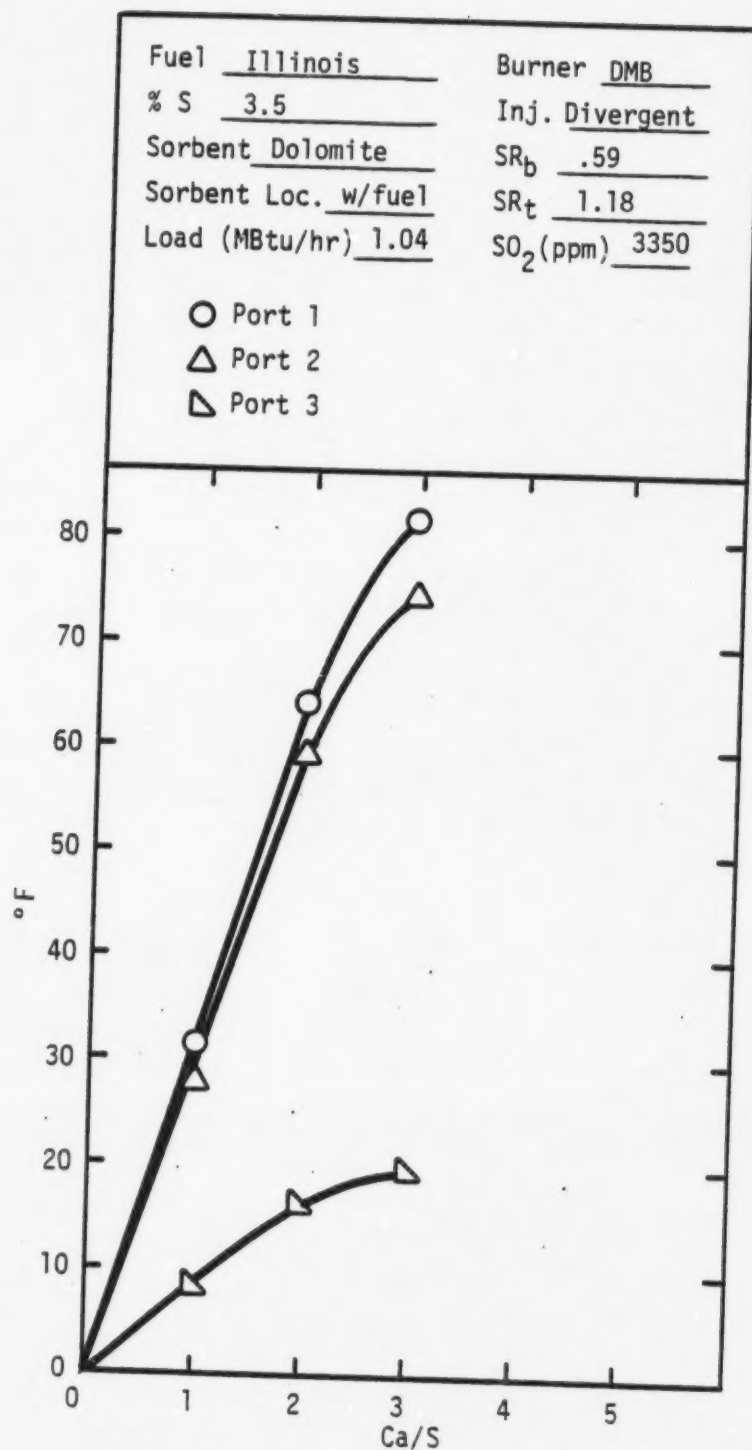


Figure E-26. Sulfur capture through BSF - Illinois coal with dolomite.

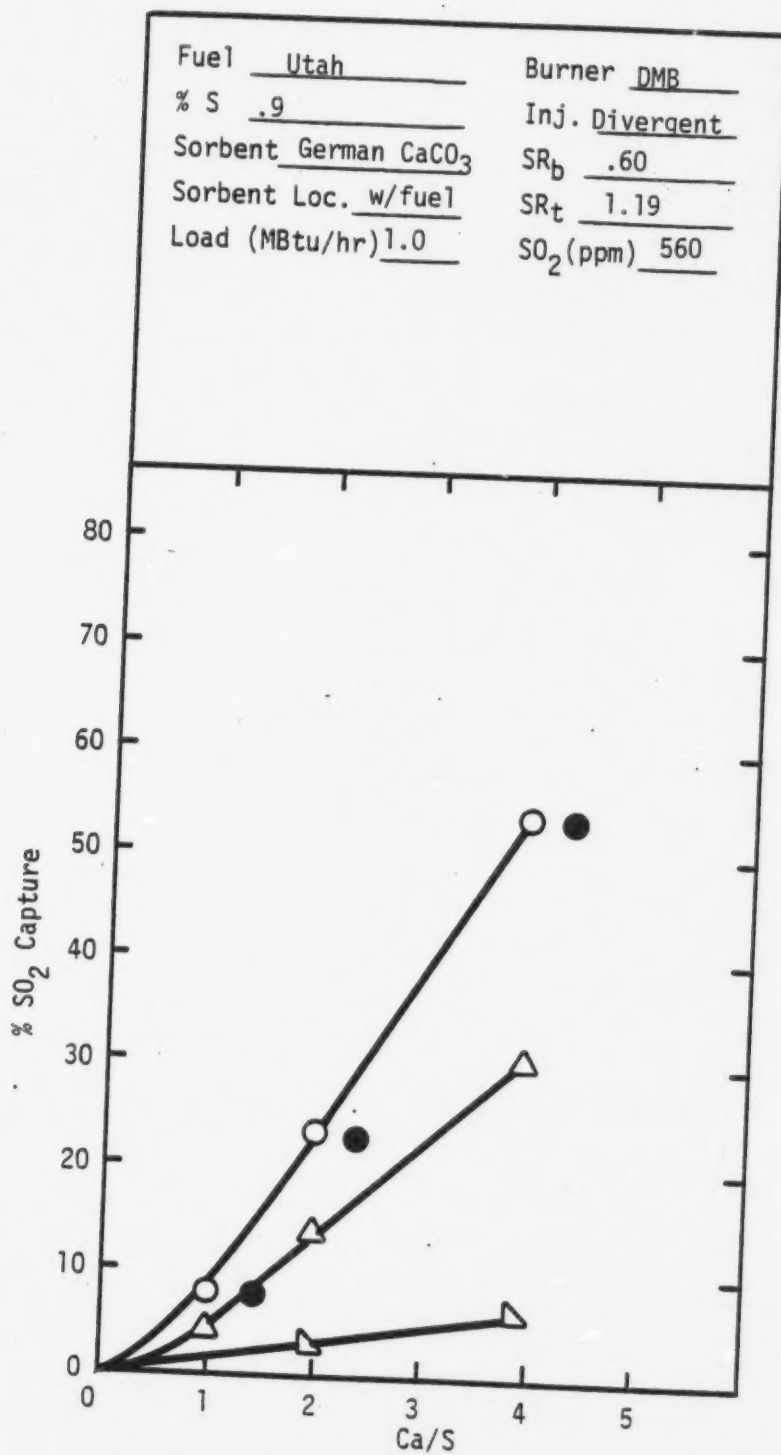


Figure E-27. Sulfur capture through BSF for Utah coal with German CaCO_3 .

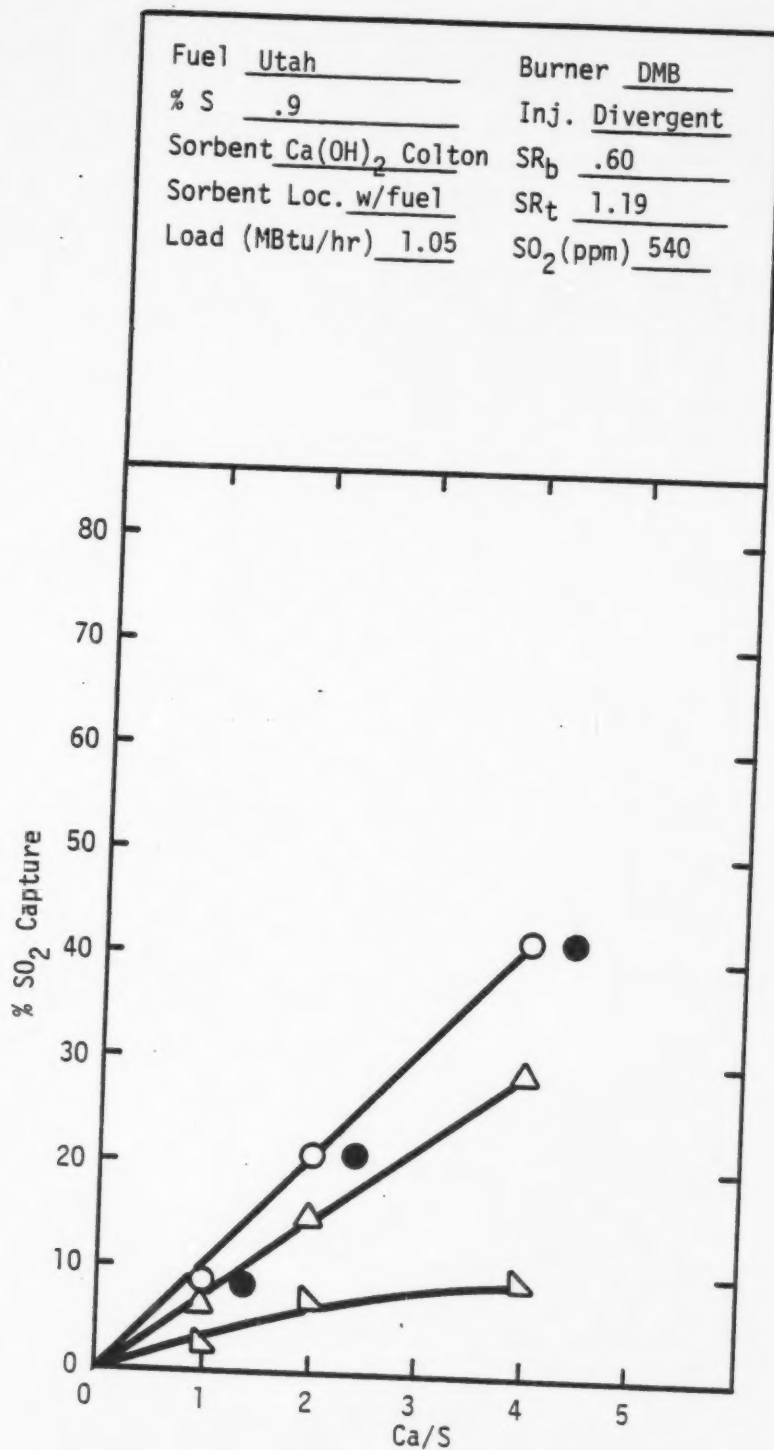


Figure E-28. Sulfur capture through the BSF Utah coal with $\text{Ca}(\text{OH})_2$ -Colton.

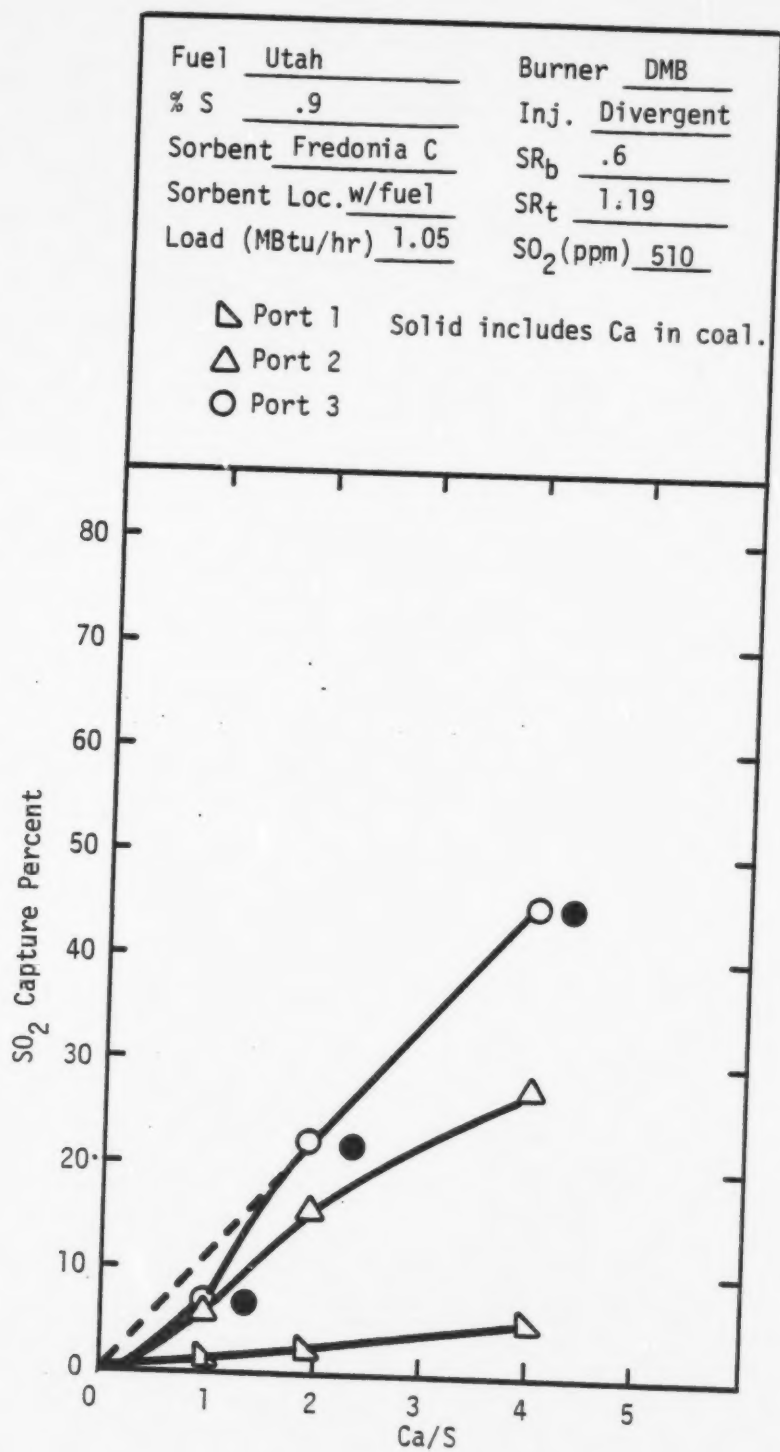


Figure E-29. Sulfur capture through BSF - Utah coal with Fredonia C.

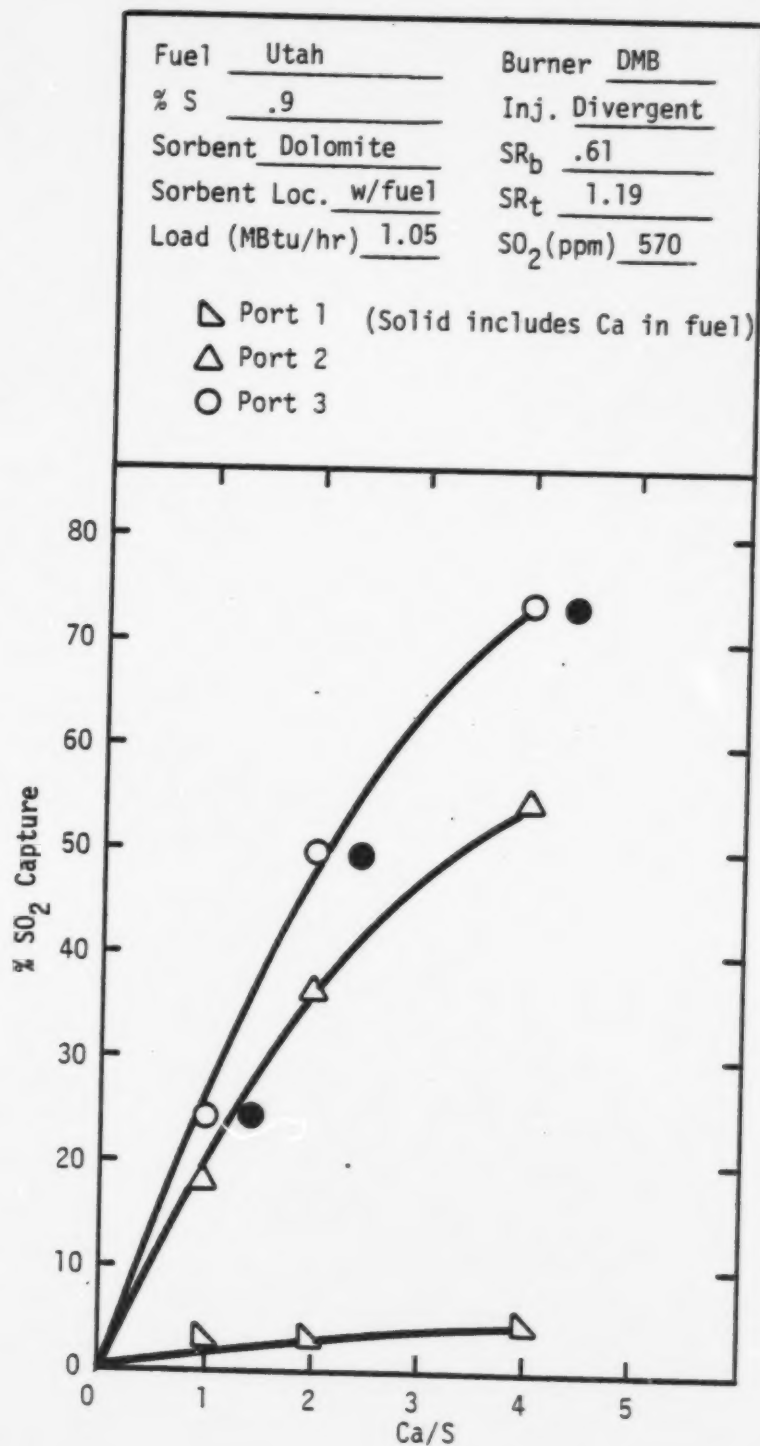


Figure E-30. Sulfur capture through BSF - Utah coal with dolomite.

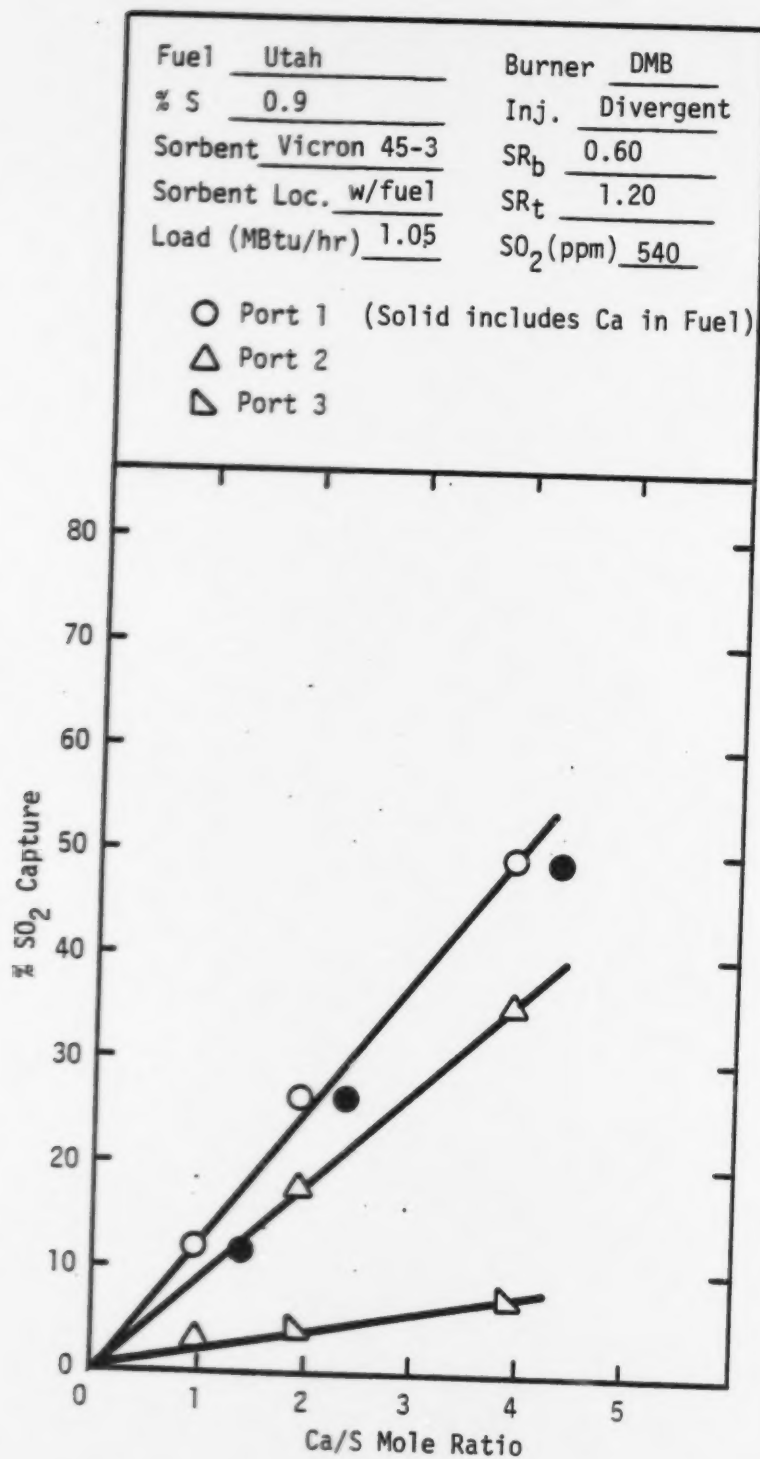


Figure E-31. Sulfur capture through BSF, Utah coal and Vicron 45-3.

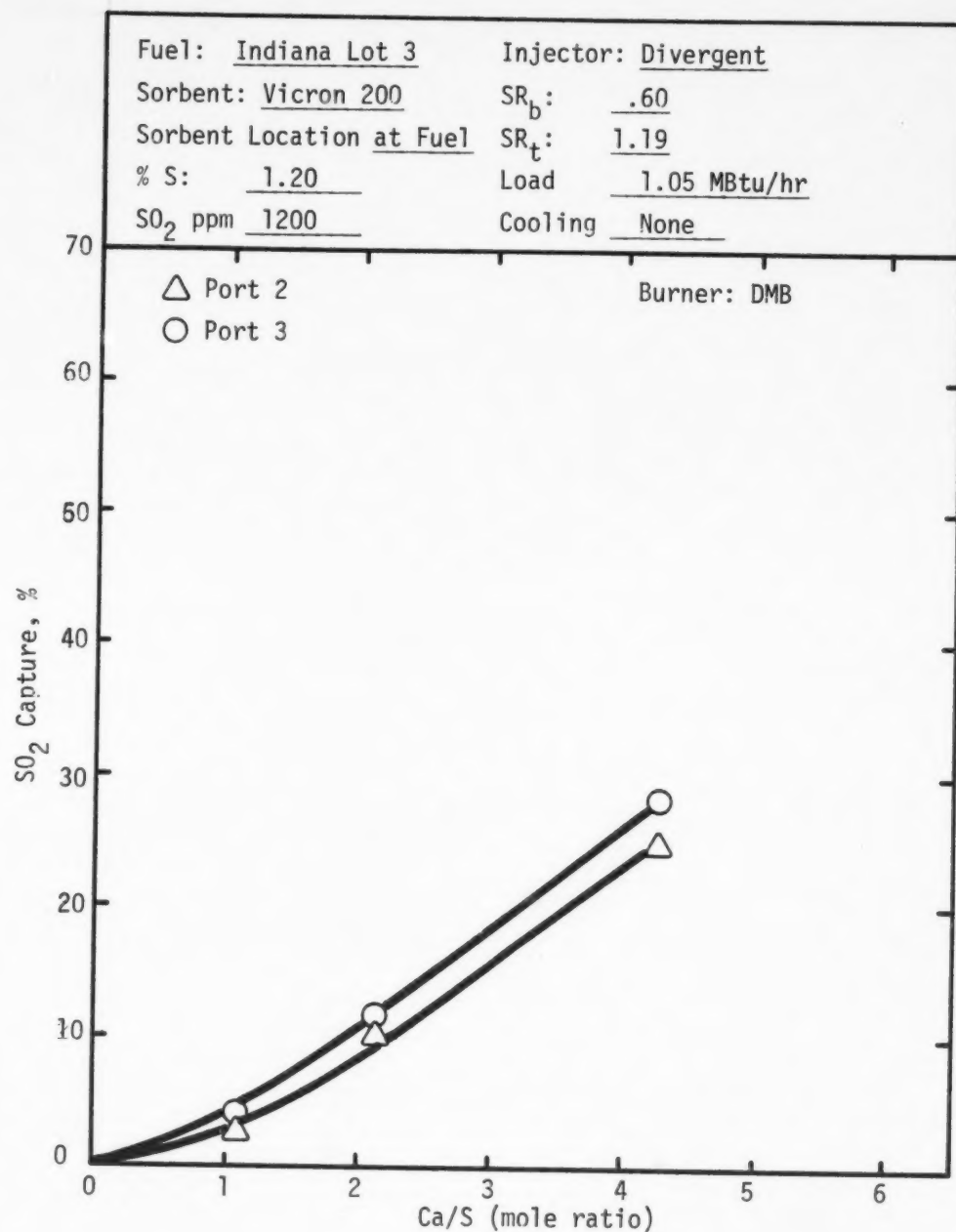


Figure E-32. Sulfur capture through BSF, Indiana L3 coal with Vicron 200.

APPENDIX F--DATA TABLES

DATA SHEET

Date <u>3-4-83</u>		Sorbent Location <u>At Fuel</u>	
Fuel <u>NAT - #2S</u>	% S <u> </u>	Cooling <u>None</u>	Location <u>N.A.</u>
Sorbent <u>Rollovic</u>		Burner <u>Axial Injector, Internally Staged</u>	

Run #s <u>3-4-1, 3-4-2</u> Load (M Btu/hr) <u>1.06</u> Air Heat <u>None</u> SRp <u>.12</u> SRB <u>.60</u> SRT <u>1.17</u> Ca/S <u>1.35</u>	Run #s <u>3-4-3, 3-4-4</u> Load (M Btu/hr) <u>1.06</u> Air Heat <u>None</u> SRp <u>.11</u> SRB <u>.60</u> SRT <u>1.17</u> Ca/S <u>2.84</u>	Run #s <u> </u> Load (M Btu/hr) <u> </u> Air Heat <u> </u> SRp <u> </u> SRB <u> </u> SRT <u> </u> Ca/S <u> </u>
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SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>1845</u> <u>1651</u> <u>1567</u> SO ₂ W <u>1711</u> <u>1374</u> <u>1096</u> % Capt. <u>7.2</u> <u>16.8</u> <u>29.8</u> % Util. <u>5.33</u> <u>12.44</u> <u>22.07</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>1653</u> <u>1593</u> <u>1492</u> SO ₂ W <u>1444</u> <u>897</u> <u>516</u> % Capt. <u>12.64</u> <u>43.7</u> <u>65.4</u> % Util. <u>4.45</u> <u>15.38</u> <u>23.03</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u> </u> <u> </u> <u> </u> SO ₂ W <u> </u> <u> </u> <u> </u> % Capt. <u> </u> <u> </u> <u> </u> % Util. <u> </u> <u> </u> <u> </u>
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Temperature Measurements Tg1 <u> </u> Tg2 <u> </u> Center Rad. <u>2750</u> Exit Rad. <u>2410</u> Exit PFC <u>1981</u> Exit Conv. <u>577</u>	Temperature Measurements Tg1 <u>Center of Radiant 2599</u> Tg2 <u>Ctr. Vert. Trans 2417</u> Center Rad. <u>2572</u> Exit Rad. <u>2410</u> Exit PFC <u>1950</u> Exit Conv. <u>571</u>	Temperature Measurements Tg1 <u> </u> Tg2 <u> </u> Center Rad. <u> </u> Exit Rad. <u> </u> Exit PFC <u> </u> Exit Conv. <u> </u>
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Solid Samples Location <u> </u> # <u> </u> % S <u> </u> % CaO <u> </u>	Solid Samples Location <u> </u> # <u> </u> % S <u> </u> % CaO <u> </u>	Solid Samples Location <u> </u> # <u> </u> % S <u> </u> % CaO <u> </u>
--	--	--

Solid Samples Location <u> </u> # <u> </u> % S <u> </u> % CaO <u> </u>	Solid Samples Location <u> </u> # <u> </u> % S <u> </u> % CaO <u> </u>	Solid Samples Location <u> </u> # <u> </u> % S <u> </u> % CaO <u> </u>
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Comments:

DATA SHEET

Date 6/2/83 Sorbent Location At Fuel
 Fuel Nat-H₂S % S Cooling None Location N/A
 Sorbent Vicron 45-3 Burner Radial Injector, DMB

Run #s 6/2-1, 6/2-2Load (M Btu/hr) 1.02Air Heat NoneSRp .13SRg .73SRT 1.22Ca/S 1.46Run #s 6/2-3, 6/3-4Load (M Btu/hr) 1.02Air Heat NoneSRp .13SRg .72SRT 1.20Ca/S 2.90Run #s Load (M Btu/hr) Air Heat SRp SRg SRT Ca/S SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 2223 1935 1901SO₂ W 2091 1223 1109% Capt. 5.94 36.8 41.66% Util. 4.06 25.2 28.53SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 2107 2016 1959SO₂ W 1820 720 502% Capt. 16.12 64.3 74.4% Util. 5.55 22.17 25.65SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. SO₂ W % Capt. % Util.

Temperature Measurements

Tg1 Tg2 Center Rad. 2683Exit Rad. 2428Exit PFC 1812Exit Conv. 624

Temperature Measurements

Tg1 Radiant 2713Tg2 Horizontal Trans. 2453Center Rad. 2685Exit Rad. 2439Exit PFC 1811Exit Conv. 627

Temperature Measurements

Tg1 Tg2 Center Rad. Exit Rad. Exit PFC Exit Conv.

Solid Samples

Location

Location

% S % CaO # % S % CaO

Solid Samples

Location

Location

% S % CaO

Exit of post-flame

6/2-4-2% S % CaO

Solid Samples

Location

Location

% S % CaO # % S % CaO

Comments:

DATA SHEET

Date 6/13/83 Sorbent Location At Fuel
 Fuel Nat-H₂S % S Cooling None Location N/A
 Sorbent Fredonia (coarse) Burner Radial Injector, DMB

Run #s 6/13-1, 6/13-2
 Load (M Btu/hr) 1.04
 Air Heat None
 SRp .11
 SRB .59
 SRT 1.21
 Ca/S 1.45

SO ₂ Measurements			
	Port 1	Port 2	Port 3
SO ₂ W.O.		1892	1748
SO ₂ W		1406	1269
% Capt.		25.7	27.4
% Util.		17.72	18.89

Temperature Measurements

Tg₁
 Tg₂
 Center Rad. 2580
 Exit Rad. 2372
 Exit PFC 1780
 Exit Conv. 528

Solid Samples	Location
#	
% S	
% CaO	

#	
% S	
% CaO	

Run #s 6/13-3, 6/13-4
 Load (M Btu/hr) 1.03
 Air Heat None
 SRp .11
 SRB .59
 SRT 1.21
 Ca/S 2.90

SO ₂ Measurements			
	Port 1	Port 2	Port 3
SO ₂ W.O.		1887	1719
SO ₂ W		1165	980
% Capt.		38.3	43.0
% Util.		13.2	14.8

Temperature Measurements

Tg₁
 Tg₂
 Center Rad. 2582
 Exit Rad. 2371
 Exit PFC 1780
 Exit Conv. 567

Solid Samples	Location
#	
% S	
% CaO	

#	6/13-4-2
% S	
% CaO	

Run #s 6/13-5, 6/13-6
 Load (M Btu/hr) 1.03
 Air Heat None
 SRp .11
 SRB .59
 SRT 1.20
 Ca/S 5.8

SO ₂ Measurements			
	Port 1	Port 2	Port 3
SO ₂ W.O.		1920	1804
SO ₂ W		836	584
% Capt.		56.5	67.6
% Util.		9.74	11.66

Temperature Measurements

Tg₁
 Tg₂
 Center Rad. 2580
 Exit Rad. 2380
 Exit PFC 1785
 Exit Conv. 606

Solid Samples	Location
#	
% S	
% CaO	

#	
% S	
% CaO	

Comments:

DATA SHEET

Date 6/15/83Sorbent Location At FuelFuel Nat-H₂S

% S _____

Cooling NoneLocation N/ASorbent Marble White 125Burner Radial Injector, DMBRun #s 6/15-1, 6/15-2Load (M Btu/hr) 1.06Air Heat NoneSRp .11SRB .59SRT 1.21Ca/S 1.51Run #s 6/15-3, 6/15-4Load (M Btu/hr) 1.03Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 2.90Run #s 6/15-5, 6/15-6Load (M Btu/hr) 1.03Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 4.34SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1878 1771SO₂ W 1585 1394% Capt. 15.6 21.28% Util. 10.33 14.09SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1886 1780SO₂ W 1215 970% Capt. 35.6 45.5% Util. 12.27 15.69SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1920 1790SO₂ W 1027 704% Capt. 46.5 60.06% Util. 10.71 13.84

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2656Exit Rad. 2475Exit PFC 1803Exit Conv. 558

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2654Exit Rad. 2470Exit PFC 1795Exit Conv. 553

Temperature Measurements

Tg1 Center of Radiant 2770Tg2 Horiz. Trans. 2530Center Rad. 2655Exit Rad. 2468Exit PFC 1797Exit Conv. 560

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Solid Samples

Location

Location
Exit of post-flame

% S _____

% CaO _____

6/15-4-2

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

DATA SHEET

Date 6/15/83Sorbent Location At FuelFuel Nat-H₂S

% S _____

Cooling NoneLocation N/ASorbent German Ca(OH)₂Burner Radial Injector, DMBRun #s 6/15-7, 6/15-8Load (M Btu/hr) 1.03Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 1.45SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.O.	1926	1791
SO ₂ W	1401	1222
% Capt.	27.3	31.77
% Util.	18.82	21.9

Run #s 6/15-9, 6/15-10Load (M Btu/hr) 1.03Air Heat NoneSRp .11SRB .60SRT 1.20Ca/S 2.88SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.O.	1893	1780
SO ₂ W	957	655
% Capt.	49.45	63.20
% Util.	17.17	21.94

Run #s 6/15-11, 6/15-12Load (M Btu/hr) 1.03Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 4.22SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.O.	1876	1770
SO ₂ W	716	378
% Capt.	61.83	78.64
% Util.	14.65	18.63

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2650Exit Rad. 2460Exit PFC 1794Exit Conv. 580

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2648Exit Rad. 2456Exit PFC 1768Exit Conv. 579

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2645Exit Rad. 2448Exit PFC 1765Exit Conv. 590

Solid Samples

Location

Location

#	% S	% CaO
_____	_____	_____

#	% S	% CaO
_____	_____	_____

Solid Samples

Location

Location

#	% S	% CaO
_____	_____	_____

#	% S	% CaO
6/15-10-2	_____	_____

Solid Samples

Location

Location

#	% S	% CaO
_____	_____	_____

#	% S	% CaO
_____	_____	_____

Comments:

DATA SHEET

Date July 29, 1983Sorbent Location At FuelFuel Natural - H₂S

% S _____

Cooling NoneLocation N.ASorbent Cotton hydrated Ca(OH)₂Burner Radial injector, D.M.B.Run #s 7-29-7, 7-29-8Load (M Btu/hr) 1.04Air Heat NoneSRp .11SRg .59SRT 1.21Ca/S .99Run #s 7-29-9, 7-29-10Load (M Btu/hr) 1.04Air Heat NoneSRp .11SRg .59SRT 1.21Ca/S 1.98Run #s 7-29-11, 7-29-12Load (M Btu/hr) 1.04Air Heat NoneSRp .11SRg .59SRT 1.21Ca/S 2.88SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1967 1923 1796SO₂ W 1839 1637 1512% Capt. 6.5 14.87 15.8% Util. 6.6 15.0 16.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1972 1972 1865SO₂ W 1842 1425 1242% Capt. 6.6 27.7 33.4% Util. 3.3 14.0 16.7SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1945 1940 1838SO₂ W 790 1279 1074% Capt. 8.0 34.1 41.6% Util. 2.8 11.8 14.4

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2620Exit Rad. 2581Exit PFC 1718Exit Conv. 571

Temperature Measurements

Tg1 Center of Rad. 2805Tg2 Ctr. of Horz trans 2382Center Rad. 2620Exit Rad. 2581Exit PFC 1728Exit Conv. 592

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2610Exit Rad. 2570Exit PFC 1742Exit Conv. 597

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

Exit of P.F.C

Exit of Conv.

7-29-10-2

% S _____

% CaO _____

7-29-10-3

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

DATA SHEET

Date 6/27/83 Sorbent Location At Fuel
 Fuel Nat-H₂S % S Cooling None Location N/A
 Sorbent Vicron 200 Burner Axial Injector, DMB

Run #s 6/27-1, 6/27-2Load (M Btu/hr) 1.01Air Heat NoneSRp .10SRB .60SRT 1.21Ca/S 1.44Run #s 6/27-3, 6/27-4Load (M Btu/hr) 1.01Air Heat NoneSRp .10SRB .60SRT 1.21Ca/S 2.89Run #s 6/27-5, 6/27-6Load (M Btu/hr) 1.02Air Heat NoneSRp .10SRB .60SRT 1.17Ca/S 4.26SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1916 1869SO₂ W 1630 1521% Capt. 16.9 18.6% Util. 11.7 12.91SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1941 1843SO₂ W 1255 1036% Capt. 35.34 43.78% Util. 12.22 15.14SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1902 1781SO₂ W 1018 732% Capt. 46.5 59.0% Util. 10.92 13.85

Temperature Measurements

Tg1 Tg2 Center Rad. 2669Exit Rad. 2448Exit PFC 1802Exit Conv. 579

Temperature Measurements

Tg1 Tg2 Exit of post flame 1879Center Rad. 2670Exit Rad. 2446Exit PFC 1804Exit Conv. 597

Temperature Measurements

Tg1 Tg2 Center Rad. 2669Exit Rad. 2443Exit PFC 1806Exit Conv. 633

Solid Samples

Location

Location

% S % CaO

Solid Samples

Location

Location

% S % CaO

Exit of post-flame

6/27-4-2% S % CaO

Solid Samples

Location

Location

% S % CaO # % S % CaO

Comments:

DATA SHEET

Date 6/2/83Sorbent Location At FuelFuel Nat-H₂S

% S _____

Cooling NoneLocation N/ASorbent Vicron 45-3Burner Radial Injector, DMBRun #s 6/2-5, 6/2-6Load (M Btu/hr) 1.80Air Heat NoneSRp .10SRg .73SRT 1.21Ca/S 1.46Run #s 6/2-7, 6/2-8Load (M Btu/hr) 1.80Air Heat NoneSRp .10SRg .74SRT 1.21Ca/S 2.95

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRg _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1835 1980 1865SO₂ W 1673 1126 861% Capt. 8.8 43.13 53.83% Util. 6.02 29.54 36.86SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1830 2047 1895SO₂ W 1579 908 496% Capt. 13.7 55.6 73.82% Util. 4.64 18.8 25.03SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2773Exit Rad. 2524Exit PFC 1910Exit Conv. 816

Temperature Measurements

Tg₁ Center of Radiant 2887Tg₂ Horizontal Trans 2572Center Rad. 2780Exit Rad. 2533Exit PFC 1934Exit Conv. 827

Temperature Measurements

Tg₁ _____Tg₂ _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

Exit of post-flame

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

DATA SHEET

Date July 19, 1983Sorbent Location At FuelFuel Natural - H₂S

% S _____

Cooling NoneLocation N.ASorbent DolomiteBurner Radial injector, D.M.B.Run #s 7-19-1, 7-19-2Load (M Btu/hr) 1.04Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 1.0Run #s 7-19-3, 7-19-4Load (M Btu/hr) 1.04Air Heat NoneSRp .11SRB .60SRT 1.21Ca/S 1.96Run #s 7-19-5, 7-19-6Load (M Btu/hr) 1.06Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 2.93SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1838 1735SO₂ W 1409 1218% Capt. 23.34 29.8% Util. 23.34 29.8SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1851 1769SO₂ W 1066 725% Capt. 42.4 59.0% Util. 21.6 30.1SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1870 1741SO₂ W 850 423% Capt. 54.5 75.7% Util. 18.6 25.8

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2666Exit Rad. 2635Exit PFC 1780Exit Conv. 663

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2666Exit Rad. 2635Exit PFC 1780Exit Conv. 664

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2666Exit Rad. 2635Exit PFC 1784Exit Conv. 680

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

DATA SHEET

Date July 24, 1983Sorbent Location At Post Flame CavityFuel Natural H₂S

% S _____

Cooling NoneLocation N.ASorbent Vicron 45-3Burner Radial injector, D.M.B.Run #s 7-24-1, 7-24-2Load (M Btu/hr) 1.05Air Heat NoneSRp .00SRB .60SRT 1.12, SRTOT 1.45Ca/S 1.48Run #s 7-24-3, 7-24-4Load (M Btu/hr) 1.05Air Heat NoneSRp 0.0SRB .60SRT 1.13, SRTOTAL 1.45Ca/S 3.00

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2057 1915 1775SO₂ W 1793 1316 1166% Capt. 12.8 31.28 34.3% Util. 8.6 21.13 23.1SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2085 1935 1827SO₂ W 1692 929 646% Capt. 19.0 52 64.6% Util. 6.3 17.3 21.53SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2703Exit Rad. 2656Exit PFC 1720Exit Conv. 705

Temperature Measurements

Tg₁ Sorbent injector 2032Tg₂ _____Center Rad. 2700Exit Rad. 2650Exit PFC 1703Exit Conv. 698

Temperature Measurements

Tg₁ _____Tg₂ _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Solid Samples

Location

Location

Exit of P.F.C. Exit of Conv.

7-24-4-2

% S _____

% CaO _____

7-24-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

Load 1.04 MBTU/hr, High oxidant and High Oxygen percent in flare gas.

DATA SHEET

Date July 24, 1983Sorbent Location AT Post Flame CavityFuel Natural - H₂S

% S _____

Cooling None

Location _____

N.A

Sorbent Colton hydrated Ca(OH)₂Burner Radial injector, D.M.BRun #s 7-24-5, 7-24-6Load (M Btu/hr) 1.05Air Heat NoneSRp 0.0SRB .60SRT 1.13, SRT 1.45Ca/S 1.49Run #s 7-24-7, 7-24-8Load (M Btu/hr) 1.05Air Heat NoneSRp 0.0SRB .60SRT 1.13, SRTOT 1.45Ca/S 3.00

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2259 1873 1797SO₂ W 2008 1546 1374% Capt. 11.0 17.45 23.54% Util. 7.38 11.7 15.8SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2319 2075 1965SO₂ W 1852 816 555% Capt. 20. 20.6 71.7% Util. 6.6 20.2 23.9SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2639Exit Rad. 2644Exit PFC 1664Exit Conv. 702

Temperature Measurements

Tg₁ Sorbent injector 2032Tg₂ _____Center Rad. 2689Exit Rad. 2644Exit PFC 1654Exit Conv. 702

Temperature Measurements

Tg₁ _____Tg₂ _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Solid Samples

Location

Location

Exit of P.F.C

Exit of Conv.

7-24-8-2

% S _____

% CaO _____

7-24-8-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

Loas 1.05 MBTU/hr, High oxident and High oxygen percent in flare gas.

DATA SHEET

Date 4/13/83 Sorbent Location At FuelFuel Nat - H₂S % S Cooling None Location N/ASorbent Vicron 45-3 Burner Axial Injector, Internally-stagedOxygen added in oil/air

21% O₂
 Run #s 4/13-1, 4/13-2
 Load (M Btu/hr) 1.06
 Air Heat 383°F
 SRp .11
 SRB 1.10
 SRT 1.18
 Ca/S 2.86

25% O₂
 Run #s 4/13-3, 4/13-4
 Load (M Btu/hr) 1.06
 Air Heat 432°F
 SRp .15
 SRB 1.05
 SRT 1.12
 Ca/S 3.0

30.5% O₂
 Run #s 4/13-5, 4/13-6
 Load (M Btu/hr) 1.06
 Air Heat 459°F
 SRp .18
 SRB 1.07
 SRT 1.14
 Ca/S 6.5

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 2023 1870
 SO₂ W 796 480
 % Capt. 6065 74.3
 % Util. 21.2 12.73

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1369
 SO₂ W 360
 % Capt. 73.70
 % Util. 24.56

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1160
 SO₂ W 33
 % Capt. 97.15
 % Util. 14.95

Temperature Measurements
 Tg1 Ctr. of Rad. 2743°F
 Tg2 Ctr. Vert. Tr. 2278°F
 Center Rad. 2673
 Exit Rad. 2509
 Exit PFC 1793
 Exit Conv. 651

Temperature Measurements
 Tg1
 Tg2
 Center Rad. 2858
 Exit Rad. 2514
 Exit PFC 1739
 Exit Conv. 518

Temperature Measurements
 Tg1
 Tg2
 Center Rad. 3020
 Exit Rad. 2557
 Exit PFC 1718
 Exit Conv. 460

Solid Samples
 Location Location Exit Post-flame
 # # 4/13-2-2
 % S % S 7.53
 % CaO % CaO 74.2

Solid Samples
 Location Location
 # #
 % S % S
 % CaO % CaO

Solid Samples
 Location Location Exit Post-flame
 # # 4/13-6-2
 % S % S 15.6
 % CaO % CaO 39.8
 SA 4.76
 % Cr 2.48

Comments:

DATA SHEET

Date 3/25/83 Sorbent Location At FuelFuel Nat - H₂S % S Cooling None Location N/ASorbent Vicron 45-3 Burner Axial Injector, Internally-stagedRun #s 3/25 - 1, 3/25 - 2Load (M Btu/hr) 1.06Air Heat NoneSRp .11SRB .59SRT 1.17Ca/S 1.48Run #s 3/25 - 3, 3/25 - 4Load (M Btu/hr) 1.06Air Heat NoneSRp .11SRB .59SRT 1.17Ca/S 2.93Run #s Load (M Btu/hr) Air Heat SRp SRB SRT Ca/S SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1954 1636SO₂ W 1480 868% Capt. 24.4 47% Util. 16.48 31.75SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2020 1857SO₂ W 1180 589% Capt. 41.6 68.3% Util. 14.19 23.31SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. SO₂ W % Capt. % Util.

Temperature Measurements

Tg₁ Tg₂ Center Rad. 2579Exit Rad. 2548Exit PFC 1835Exit Conv. 714

Temperature Measurements

Tg₁ Center of Rad 2659Tg₂ Center of Ver.Tr. 2304Center Rad. 2579Exit Rad. 2547Exit PFC 1838Exit Conv. 719

Temperature Measurements

Tg₁ Tg₂ Center Rad. Exit Rad. Exit PFC Exit Conv.

Solid Samples

Location

Location

#

% S % CaO

#

% S % CaO

Solid Samples

Location

Location

#

% S % CaO

#

% S % CaO

Solid Samples

Location

Location

#

% S % CaO

#

% S % CaO

Comments:

DATA SHEET

Date July 29, 1983 Sorbent Location At Fuel
 Fuel Natural - H₂S % S Cooling None Location N.A.
 Sorbent German CA CO₃ Burner Radiant injector, D.M.B.

Run #s 7-29-1, 7-29-2Load (M Btu/hr) 1.05Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S .99Run #s 7-29-3, 7-29-4Load (M Btu/hr) 1.05Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 2.00Run #s 7-29-5, 7-29-6Load (M Btu/hr) 1.06Air Heat NoneSRp .11SRB .59SRT 1.20Ca/S 3.04SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1826 1779 1704SO₂ W 1748 1535 1428% Capt. 4.27 13.7 16.2% Util. 4.2 13.8 16.4SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1960 1928 1864SO₂ W 1830 1397 1223% Capt. 6.6 27.5 34.4% Util. 3.3 13.75 17.2SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1974 1962 1863SO₂ W 1851 1238 1000% Capt. 6.2 36.9 46.3% Util. 2.04 12.01 15.2

Temperature Measurements

Tg1 Tg2 Center Rad. 2620Exit Rad. 2581Exit PFC 1714Exit Conv. 534

Temperature Measurements

Tg1 Center of Rad. 2805Tg2 Ctr of Horz tran 2482Center Rad. 2620Exit Rad. 2581Exit PFC 1713Exit Conv. 550

Temperature Measurements

Tg1 Tg2 Center Rad. 2620Exit Rad. 2580Exit PFC 1719Exit Conv. 571

Solid Samples

Location

Location

% S % CaO

Solid Samples

Location

Location

Exit of P.F.C

Exit of Conv.

7-29-4-2% S % CaO # 7-29-4-3% S % CaO

Solid Samples

Location

Location

% S % CaO # % S % CaO

Comments:

DATA SHEET

Date July 20, 1983Sorbent Location With FuelFuel Indiana 3% S 1.29Cooling NoneLocation N.ASorbent Marble White 125Burner Divergent injector, D.M.B.Run #s 7-20-7, 7-20-8Load (M Btu/hr) 1.06Air Heat NoneSRp .21SRg .59SRT 1.18Ca/S 1.08Run #s 7-20-9, 7-20-10Load (M Btu/hr) 1.06Air Heat NoneSRp .21SRg .60SRT 1.19Ca/S 2.15Run #s 7-20-11, 7-20-12Load (M Btu/hr) 1.06Air Heat NoneSRp .21SRg .59SRT 1.19Ca/S 4.35SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1281 1209SO₂ W 1233 1150% Capt. 3.8 4.9% Util. 3.5 4.5SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1256 1189SO₂ W 1152 1078% Capt. 8.3 9.34% Util. 3.8 4.3SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1299 1220SO₂ W 1080 994% Capt. 16.86 18.52% Util. 3.8 4.20

Temperature Measurements

Tg1 Tg2 Center Rad. 2712Exit Rad. 2674Exit PFC 1789Exit Conv. 666

Temperature Measurements

Tg1 Tg2 Center Rad. 2712Exit Rad. 2674Exit PFC 1789Exit Conv. 674

Temperature Measurements

Tg1 Tg2 Center Rad. 2710Exit Rad. 2672Exit PFC 1788Exit Conv. 674

Solid Samples

Location Location

% S % S % CaO % CaO

Solid Samples

Location Location

Exit of P.F.C Exit of conv.

7-20-10-2 # 7-20-10-3% S % S % CaO % CaO

Solid Samples

Location Location

% S % S % CaO % CaO

Comments:

DATA SHEET

Date July 20, 1983Sorbent Location With FuelFuel Indiana 3 % S 1.29 Cooling None Location N.A.Sorbent Cotton hydrated Ca(OH)₂ Burner Divergent injector, D.M.BRun #s 7-20-13, 7-20-14Load (M Btu/hr) 1.04Air Heat NoneSRp .21SRB 60SRT 1.20Ca/S 1.09Run #s 7-20-15, 7-20-16Load (M Btu/hr) 1.04Air Heat NoneSRp .21SRB 60SRT 1.20Ca/S 2.10Run #s 7-20-17, 7-20-18Load (M Btu/hr) 1.04Air Heat NoneSRp .21SRB 60SRT 1.20Ca/S 4.38SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1264 1201SO₂ W 1221 1141% Capt. 3.4 5.0% Util. 3.3 4.9SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1333 1266SO₂ W 1240 1140% Capt. 7.0 10.0% Util. 3.1 4.5SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1333 1266SO₂ W 1096 989% Capt. 17.8 21.9% Util. 4.06 5.0

Temperature Measurements

Tg1

Tg2

Center Rad. 2700Exit Rad. 2662Exit PFC 1779Exit Conv. 682

Temperature Measurements

Tg1

Tg2

Center Rad. 2700Exit Rad. 2662Exit PFC 1781Exit Conv. 689

Temperature Measurements

Tg1

Tg2

Center Rad. 2701Exit Rad. 2662Exit PFC 1783Exit Conv. 689

Solid Samples

Location

Location

#

% S

% CaO

Solid Samples

Location

Location

Exit of P.F.C.

Exit of Conv.

7-20-16-2

% S

% CaO

7-20-16-3

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

DATA SHEET

Date July 20, 1983 Sorbent Location With Fuel
 Fuel Indiana 3 % S 1.29 Cooling None Location N.A.
 Sorbent Vicron 200 Burner Divergent injector, D.M.B.

Run #s 7-20-1, 7-20-2
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .20
 SRg .60
 SRT 1.19
 Ca/S 1.07

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1108 1061
 SO₂ W 1078 1020
 % Capt. 2.7 3.86
 % Util. 2.5 3.5

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2714
 Exit Rad. 2665
 Exit PFC 1789
 Exit Conv. 615

Solid Samples
 Location Location

 % S _____
 % CaO _____

Run #s 7-20-3, 7-20-4
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .21
 SRg .60
 SRT 1.19
 Ca/S 2.15

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1149 1098
 SO₂ W 1032 969
 % Capt. 10.18 11.75
 % Util. 4.7 5.4

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2714
 Exit Rad. 2665
 Exit PFC 1790
 Exit Conv. 628

Solid Samples
 Location Location

 % S _____
 % CaO _____

Run #s 7-20-5, 7-20-6
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .21
 SRg .60
 SRT 1.19
 Ca/S 4.27

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1176 1112
 SO₂ W 884 800
 % Capt. 24.83 28.05
 % Util. 5.8 4.6

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2714
 Exit Rad. 2664
 Exit PFC 1791
 Exit Conv. 641

Solid Samples
 Location Location

7-20-6-2 # 7-20-6-3
 % S _____
 % CaO _____

Comments:

DATA SHEET

Date July 25, 1983Sorbent Location With fuelFuel SARR Coal% S .76Cooling NoneLocation N.A.Sorbent Vicron 45-3Burner Divergent injector, D.M.BRun #s 7-25-1, 7-25-2Load (M Btu/hr) 1.04Air Heat NoneSRp .20SRB .60SRT 1.20Ca/S 1.71Run #s 7-25-3, 7-25-4Load (M Btu/hr) 1.04Air Heat NoneSRp .20SRB .59SRT 1.20Ca/S 3.46Run #s 7-25-5, 7-25-6Load (M Btu/hr) 1.04Air Heat NoneSRp .20SRB .59SRT 1.20Ca/S 4.62SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 681 526 456SO₂ W 667 480 392% Capt. 2.05 8.7 14.0% Util. 1.2 5.1 8.2SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 665 568 490SO₂ W 622 433 310% Capt. 6.5 23.8 36.7% Util. 1.87 6.87 10.6SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 665 568 490SO₂ W 609 327 204% Capt. 8.42 42.4 58.36% Util. 1.82 9.17 12.63

Temperature Measurements

Tg₁Tg₂Center Rad. 2648Exit Rad. 2630Exit PFC 1839Exit Conv. 709

Temperature Measurements

Tg₁ Center of Rad 2739Tg₂ Gen. of Horz. tran 2468Center Rad. 2630Exit Rad. 2612Exit PFC 1843Exit Conv. 718

Temperature Measurements

Tg₁Tg₂Center Rad. 2630Exit Rad. 2610Exit PFC 1840Exit Conv. 715

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location

Exit of P.F.C.

Exit of Conv.

7-25-4-2

% S

% CaO

7-25-4-3

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

DATA SHEET

Date 5/23/83 Sorbent Location At Fuel
 Fuel Utah % S .90 Cooling None Location N/A
 Sorbent Fredonia (coarse) Burner Divergent Injector, Internally Staged

Run #s 5/23-1, 5/23-2Load (M Btu/hr) 1.05Air Heat NoneSRp .21SRB .60SRT 1.19Ca/S 1.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 586 576 510SO₂ W 580 541 466% Capt. 1.0 6.0 7.0% Util. 1.0 6.0 7.0Run #s 5/23-3, 5/23-4Load (M Btu/hr) 1.06Air Heat NoneSRp .21SRB .60SRT 1.18Ca/S 1.97SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 587 577 512SO₂ W 573 485 398% Capt. 2.4 15.94 22.3% Util. 1.22 8.09 11.32Run #s 5/23-5, 5/23-6Load (M Btu/hr) 1.04Air Heat NoneSRp .22SRB .59SRT 1.19Ca/S 4.02SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 627 630 562SO₂ W 593 457 309% Capt. 5.42 27.5 45.0% Util. 1.34 6.84 11.2

Temperature Measurements

Tg1

Tg2

Center Rad. 2709Exit Rad. 2459Exit PFC 1826Exit Conv. 674

Temperature Measurements

Tg1

Tg2

Center Rad. 2716Exit Rad. 2459Exit PFC 1910Exit Conv. 681

Temperature Measurements

Tg1 Center of Radian 2768Tg2 Center of H. Trans 2594Center Rad. 2718Exit Rad. 2467Exit PFC 1874Exit Conv. 590

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location
Exit of Post-flame

#

% S

% CaO

5/23-4-2

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

DATA SHEET

Date 5/23/83Sorbent Location At FuelFuel Utah% S .90Cooling NoneLocation N/ASorbent German Ca(OH)₂Burner Divergent Injector, Internally StagedRun #s 5/23-7, 5/23-8Load (M Btu/hr) 1.04Air Heat NoneSRp .21SRB .58SRT 1.17Ca/S .99SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 607 562SO₂ W 582 517% Capt. 4.1 8.0% Util. 4.1 8.0Run #s 5/23-9, 5/23-10Load (M Btu/hr) 1.06Air Heat NoneSRp .21SRB .60SRT 1.19Ca/S 1.94SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 610 610 554SO₂ W 590 522 425% Capt. 3.1 14.4 23.3% Util. 1.6 7.42 12.0Run #s 5/23-11, 5/23-12Load (M Btu/hr) 1.06Air Heat NoneSRp .21SRB .60SRT 1.19Ca/S 3.88SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 610 610 554SO₂ W 573 424 275% Capt. 6.06 30.5 50.36% Util. 1.56 7.9 13.0

Temperature Measurements

Tg₁ Center of Rad 2768Tg₂ Center of H. Trans 2594Center Rad. 2705Exit Rad. 2464Exit PFC 1809Exit Conv. 560

Temperature Measurements

Tg₁Tg₂Center Rad. 2732Exit Rad. 2462Exit PFC 1815Exit Conv. 592

Temperature Measurements

Tg₁Tg₂Center Rad. 2698Exit Rad. 2465Exit PFC 1852Exit Conv. 598

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

DATA SHEET

Date 5/24/83 Sorbent Location At Fuel
 Fuel Indiana L3 % S 1.23 Cooling None Location N/A
 Sorbent Vicron 45-3 Burner Divergent Injector, Internally Staged

Run #s 5/24-1, 5/24-2Load (M Btu/hr) 1.03Air Heat NoneSRp .21SRB .61SRT 1.19Ca/S 1.12Run #s 5/24-3, 5/24-4Load (M Btu/hr) 1.04Air Heat NoneSRp .21SRB .60SRT 1.19Ca/S 2.24Run #s 5/24-5, 5/24-6Load (M Btu/hr) 1.04Air Heat NoneSRp .21SRB .60SRT 1.18Ca/S 4.46SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 795 752 735SO₂ W 772 715 680% Capt. 3.0 4.9 7.48% Util. 2.68 4.8 6.68SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 871 847 816SO₂ W 829 697 633% Capt. 4.82 17.7 22.42% Util. 2.15 7.9 10.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 864 854 815SO₂ W 803 473 413% Capt. 7.06 44.6 49.3% Util. 1.58 10.0 11.05

Temperature Measurements

Tg1

Tg2

Center Rad. 2688Exit Rad. 2440Exit PFC 1832Exit Conv. 528

Temperature Measurements

Tg1

Tg2

Center Rad. 2679Exit Rad. 2444Exit PFC 1832Exit Conv. 544

Temperature Measurements

Tg1 Center of Radiant 2746Tg2 Center of H Trans 2574Center Rad. 2700Exit Rad. 2442Exit PFC 1831Exit Conv. 552

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location

Exit of Post-flame

#

% S

% CaO

5/24-4-2

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

DATA SHEET

Date 5/24/83 Sorbent Location At Fuel
 Fuel Indiana L3 % S 1.23 Cooling None Location N/A
 Sorbent Dolomite Burner Divergent Injector, Internally Staged

Run #s 5/24-7, 5/24-8
 Load (M Btu/hr) 1.03
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 1.16

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 929 915 866
 SO₂ W 896 795 733
 % Capt. 3.6 13.11 15.36
 % Util. 3.1 11.3 13.24

Temperature Measurements
 Tg1 Center of Rad 2746
 Tg2 Center of H. Trans 2574
 Center Rad. 2709
 Exit Rad. 2442
 Exit PFC 1820
 Exit Conv. 568

Solid Samples
 Location Location
 #
 % S
 % CaO

Run #s 5/24-9, 5/24-10
 Load (M Btu/hr) 1.03
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 2.2

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 914 905 852
 SO₂ W 837 574 505
 % Capt. 8.42 36.6 40.72
 % Util. 3.82 16.63 18.5

Temperature Measurements
 Tg1
 Tg2
 Center Rad. 2701
 Exit Rad. 2448
 Exit PFC 1826
 Exit Conv. 575

Solid Samples
 Location Location
 #
 % S
 % CaO

Run #s 5/24-11, 5/24-12
 Load (M Btu/hr) 1.03
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 4.34

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 935 942 885
 SO₂ W 823 269 201
 % Capt. 12.0 71.44 77.3
 % Util. 2.76 16.46 17.81

Temperature Measurements
 Tg1
 Tg2
 Center Rad. 2739
 Exit Rad. 2444
 Exit PFC 1827
 Exit Conv. 579

Solid Samples
 Location Location
 #
 % S
 % CaO

Comments:

DATA SHEET

Date 5/25/83 Sorbent Location At Fuel
 Fuel Indiana L3 % S 1.21 Cooling None Location N/A
 Sorbent Fredonia (coarse) Burner Divergent Injector, Internally Staged

Run #s <u>5/25-1, 5/25-2</u> Load (M Btu/hr) <u>1.03</u> Air Heat <u>None</u> SRp <u>.22</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>1.07</u>	Run #s <u>5/25-3, 5/25-4</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.22</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>2.12</u>	Run #s <u>5/25-5, 5/25-6</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.22</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>4.22</u>
SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>883</u> <u>845</u> <u>797</u> SO ₂ W <u>876</u> <u>822</u> <u>756</u> % Capt. <u>0.8</u> <u>2.7</u> <u>5.1</u> % Util. <u>.75</u> <u>2.52</u> <u>4.77</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>891</u> <u>875</u> <u>816</u> SO ₂ W <u>845</u> <u>742</u> <u>671</u> % Capt. <u>5.16</u> <u>15.2</u> <u>17.8</u> % Util. <u>2.43</u> <u>7.16</u> <u>8.4</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>961</u> <u>946</u> <u>886</u> SO ₂ W <u>864</u> <u>664</u> <u>588</u> % Capt. <u>10.0</u> <u>29.8</u> <u>33.63</u> % Util. <u>2.36</u> <u>7.06</u> <u>8.03</u>
Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2709</u> Exit Rad. <u>2400</u> Exit PFC <u>1800</u> Exit Conv. <u>562</u>	Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2722</u> Exit Rad. <u>2402</u> Exit PFC <u>1801</u> Exit Conv. <u>564</u>	Temperature Measurements Tg1 <u>Center of Rad 2758</u> Tg2 <u>Center of H. Trans 2518</u> Center Rad. <u>2736</u> Exit Rad. <u>2441</u> Exit PFC <u>1804</u> Exit Conv. <u>571</u>
Solid Samples Location _____ # _____ % S _____ % CaO _____	Solid Samples Location _____ # _____ % S _____ % CaO _____	Solid Samples Location _____ # _____ % S _____ % CaO _____
Solid Samples Location _____ # _____ % S _____ % CaO _____		
Solid Samples Location _____ # _____ % S _____ % CaO _____		

Comments:

DATA SHEET

Date <u>5/25/83</u>		Sorbent Location <u>At Fuel</u>	
Fuel <u>Indiana L3</u>	% S <u>1.21</u>	Cooling <u>None</u>	Location <u>N/A</u>
Sorbent <u>German Ca(OH)₂</u>		Burner <u>Divergent Injector, Internally Staged</u>	

Run #s <u>5/25-7</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.18</u> Ca/S <u>1.07</u>	Run #s <u>5/25-9, 5/25-10</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.18</u> Ca/S <u>2.16</u>	Run #s <u>5/25-11, 5/25-12</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.22</u> SRB <u>.61</u> SRT <u>1.18</u> Ca/S <u>4.29</u>
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SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>972</u> <u>964</u> <u>907</u> SO ₂ W <u>950</u> <u>908</u> <u>839</u> % Capt. <u>2.3</u> <u>5.8</u> <u>7.4</u> % Util. <u>2.15</u> <u>5.42</u> <u>6.91</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>947</u> <u>940</u> <u>890</u> SO ₂ W <u>874</u> <u>785</u> <u>697</u> % Capt. <u>7.7</u> <u>16.5</u> <u>21.7</u> % Util. <u>3.56</u> <u>7.63</u> <u>10.04</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>979</u> <u>963</u> <u>911</u> SO ₂ W <u>826</u> <u>606</u> <u>510</u> % Capt. <u>15.6</u> <u>37.1</u> <u>44.0</u> % Util. <u>3.63</u> <u>8.64</u> <u>10.25</u>
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Temperature Measurements Tg ₁ <u>Center of Rad 2758</u> Tg ₂ <u>Center of H.Trans 2518</u> Center Rad. <u>2721</u> Exit Rad. <u>2431</u> Exit PFC <u>1800</u> Exit Conv. <u>573</u>	Temperature Measurements Tg ₁ _____ Tg ₂ _____ Center Rad. <u>2714</u> Exit Rad. <u>2485</u> Exit PFC <u>1804</u> Exit Conv. <u>573</u>	Temperature Measurements Tg ₁ _____ Tg ₂ _____ Center Rad. <u>2724</u> Exit Rad. <u>2435</u> Exit PFC <u>1809</u> Exit Conv. <u>582</u>
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Solid Samples Location	Location	Solid Samples Location	Location	Solid Samples Location	Location
# _____	# _____	# _____	# <u>5/25-10-2</u>	# _____	# _____
% S _____	% S _____	% S _____	% S _____	% S _____	% S _____
% CaO _____	% CaO _____	% CaO _____	% CaO _____	% CaO _____	% CaO _____

Comments:

F-24

DATA SHEET

Date <u>5/27/83</u>		Sorbent Location <u>At Fuel</u>	
Fuel <u>Indiana L3</u>	% S <u> </u>	Cooling <u>None</u>	Location <u>N/A</u>
Sorbent <u>Vicron 45-3, K₂CO₃</u>		Burner <u>Divergent Injector, Internally Staged</u>	

Run #s <u>5/27-1, 5/27-2</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>1.07</u>	Run #s <u>5/27-3, 5/27-4</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>2.15</u>	Run #s <u>5/27-5, 5/27-6</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.60</u> SRT <u>1.19</u> Ca/S <u>4.22</u>
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SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>865</u> <u>862</u> <u>829</u> SO ₂ W <u>833</u> <u>780</u> <u>735</u> % Capt. <u>3.7</u> <u>9.5</u> <u>11.34</u> % Util. <u>3.45</u> <u>8.87</u> <u>10.6</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>875</u> <u>863</u> <u>827</u> SO ₂ W <u>787</u> <u>659</u> <u>598</u> % Capt. <u>10.0</u> <u>23.64</u> <u>27.7</u> % Util. <u>4.65</u> <u>11.0</u> <u>12.9</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>947</u> <u>935</u> <u>899</u> SO ₂ W <u>802</u> <u>540</u> <u>477</u> % Capt. <u>15.3</u> <u>42.3</u> <u>47.0</u> % Util. <u>3.62</u> <u>10.02</u> <u>11.13</u>
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Temperature Measurements Tg1 <u> </u> Tg2 <u> </u> Center Rad. <u>2635</u> Exit Rad. <u>2348</u> Exit PFC <u>1797</u> Exit Conv. <u>477</u>	Temperature Measurements Tg1 <u> </u> Tg2 <u> </u> Center Rad. <u>2637</u> Exit Rad. <u>2359</u> Exit PFC <u>1796</u> Exit Conv. <u>490</u>	Temperature Measurements Tg1 <u>Center of Rad 2728</u> Tg2 <u>Center of H Trans 2480</u> Center Rad. <u>2676</u> Exit Rad. <u>2369</u> Exit PFC <u>1795</u> Exit Conv. <u>503</u>
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Solid Samples Location	Location	Solid Samples Location	Location
# <u> </u>	# <u> </u>	# <u> </u>	# <u> </u>
% S <u> </u>	% S <u> </u>	% S <u> </u>	% S <u> </u>
% CaO <u> </u>	% CaO <u> </u>	% CaO <u> </u>	% CaO <u> </u>

Solid Samples Location	Location Exit of Post-flame	Solid Samples Location	Location
# <u> </u>	# <u>5/27-4-2</u>	# <u> </u>	# <u> </u>
% S <u> </u>	% S <u> </u>	% S <u> </u>	% S <u> </u>
% CaO <u> </u>	% CaO <u> </u>	% CaO <u> </u>	% CaO <u> </u>

Comments:

DATA SHEET

Date 5/31/83 Sorbent Location At Fuel
 Fuel Illinois % S 3.50 Cooling None Location N/A
 Sorbent Vicron 45-3 Burner Divergent Injector, Internally Staged

Run #s 5/31-5, 5/31-6Load (M Btu/hr) 1.02Air Heat NoneSRp .22SRB .59SRT 1.19Ca/S 1.07Run #s 5/31-7, 5/31-8Load (M Btu/hr) 1.03Air Heat NoneSRp .22SRB .59SRT 1.19Ca/S 2.14Run #s 5/31-9, 5/31-10Load (M Btu/hr) 1.03Air Heat NoneSRp .22SRB .59SRT 1.18Ca/S 4.27SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 3214SO₂ W 2743% Capt. 14.65% Util. 13.7SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 3176SO₂ W 1609% Capt. 49.33% Util. 23.05SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 3452 3445 3296SO₂ W 2867 934 679% Capt. 16.94 72.89 79.34% Util. 4.0 17.07 18.6

Temperature Measurements

Tg1 Center of Rad 2716Tg2 Center of H Trans 2507Center Rad. 2603Exit Rad. 2443Exit PFC 1868Exit Conv. 583

Temperature Measurements

Tg1 Tg2 Center Rad. 2616Exit Rad. 2436Exit PFC 1861Exit Conv. 592

Temperature Measurements

Tg1 Tg2 Center Rad. 2620Exit Rad. 2440Exit PFC 1862Exit Conv. 595

Solid Samples

Location

Location

#

% S % CaO

Solid Samples

Location

Location

#

% S % CaO

#

% S % CaO

Solid Samples

Location

Location

#

% S % CaO

#

% S % CaO

Comments:

DATA SHEET

Date 5/20/83 Sorbent Location At Fuel
 Fuel Utah % S 0.90 Cooling None Location N/A
 Sorbent Vicron 45-3 Burner Divergent Injection, Internally Staged

Run #s <u>5/20-1, 5/20-2</u>		Run #s <u>5/20-3, 5/20-4</u>		Run #s <u>5/20-6, 5/20-7</u>	
Load (M Btu/hr) <u>1.05</u>		Load (M Btu/hr) <u>1.05</u>		Load (M Btu/hr) <u>1.04</u>	
Air Heat <u>None</u>		Air Heat <u>None</u>		Air Heat <u>None</u>	
SRp <u>.20</u>		SRp <u>.20</u>		SRp <u>.20</u>	
SRB <u>.60</u>		SRB <u>.60</u>		SRB <u>.61</u>	
SRT <u>1.20</u>		SRT <u>1.19</u>		SRT <u>1.19</u>	
Ca/S <u>0.98</u>		Ca/S <u>1.96</u>		Ca/S <u>3.92</u>	
SO ₂ Measurements Port 1 Port 2 Port 3		SO ₂ Measurements Port 1 Port 2 Port 3		SO ₂ Measurements Port 1 Port 2 Port 3	
SO ₂ W.O. <u>565</u> <u>528</u> <u>522</u>		SO ₂ W.O. <u>580</u> <u>565</u> <u>524</u>		SO ₂ W.O. <u>616</u> <u>614</u> <u>556</u>	
SO ₂ W <u>561</u> <u>512</u> <u>461</u>		SO ₂ W <u>557</u> <u>465</u> <u>386</u>		SO ₂ W <u>572</u> <u>397</u> <u>282</u>	
% Capt. <u>0.0</u> <u>3.0</u> <u>11.7</u>		% Capt. <u>4.0</u> <u>17.73</u> <u>26.34</u>		% Capt. <u>7.14</u> <u>35.34</u> <u>49.28</u>	
% Util. <u>0.0</u> <u>3.06</u> <u>11.94</u>		% Util. <u>2.04</u> <u>9.04</u> <u>13.43</u>		% Util. <u>1.82</u> <u>9.01</u> <u>12.57</u>	
Temperature Measurements		Temperature Measurements		Temperature Measurements	
Tg1 _____		Tg1 _____		Tg1 _____	
Tg2 _____		Tg2 _____		Tg2 _____	
Center Rad. <u>2664</u>		Center Rad. <u>2643</u>		Center Rad. <u>2673</u>	
Exit Rad. <u>2444</u>		Exit Rad. <u>2440</u>		Exit Rad. <u>2457</u>	
Exit PFC <u>1800</u>		Exit PFC <u>1800</u>		Exit PFC <u>1802</u>	
Exit Conv. <u>507</u>		Exit Conv. <u>519</u>		Exit Conv. <u>532</u>	
Solid Samples Location		Solid Samples Location		Solid Samples Location	
Location		Location		Location	
#	#	#	# <u>5/20-4-2</u>	#	#
% S _____	% S _____	% S _____	% S _____	% S _____	% S _____
% CaO _____	% CaO _____	% CaO _____	% CaO _____	% CaO _____	% CaO _____

Comments:

DATA SHEET

Date <u>5/20/83</u>		Sorbent Location <u>At Fuel</u>	
Fuel <u>Utah</u>	% S <u>.90</u>	Cooling <u>None</u>	Location <u>N/A</u>
Sorbent <u>Dolomite</u>		Burner <u>Divergent Injector, Internally Staged</u>	

Run #s <u>5/20-7, 5/20-8</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.20</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>1.0</u>	Run #s <u>5/20-9, 5/20-10</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.20</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>2.01</u>	Run #s <u>5/20-11, 5/20-12</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.20</u> SRB <u>.61</u> SRT <u>1.18</u> Ca/S <u>4.0</u>
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SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>625</u> <u>634</u> <u>570</u> SO ₂ W <u>606</u> <u>518</u> <u>431</u> % Capt. <u>3.0</u> <u>18.3</u> <u>24.4</u> % Util. <u>3.0</u> <u>18.3</u> <u>24.4</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>622</u> <u>620</u> <u>552</u> SO ₂ W <u>594</u> <u>393</u> <u>278</u> % Capt. <u>3.0</u> <u>36.61</u> <u>49.63</u> % Util. <u>1.49</u> <u>18.21</u> <u>24.69</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>625</u> <u>632</u> <u>552</u> SO ₂ W <u>598</u> <u>287</u> <u>146</u> % Capt. <u>4.3</u> <u>54.6</u> <u>73.6</u> % Util. <u>1.08</u> <u>13.65</u> <u>18.4</u>
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Temperature Measurements Tg ₁ _____ Tg ₂ _____ Center Rad. <u>2677</u> Exit Rad. <u>2453</u> Exit PFC <u>1802</u> Exit Conv. <u>552</u>	Temperature Measurements Tg ₁ _____ Tg ₂ _____ Center Rad. <u>2710</u> Exit Rad. <u>2446</u> Exit PFC <u>1802</u> Exit Conv. <u>554</u>	Temperature Measurements Tg ₁ _____ Tg ₂ _____ Center Rad. <u>2705</u> Exit Rad. <u>2451</u> Exit PFC <u>1804</u> Exit Conv. <u>563</u>
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Solid Samples Location	Location	Solid Samples Location	Location	Solid Samples Location	Location
# _____	# _____	# _____	# _____	# _____	# _____
% S _____	% S _____	% S _____	% S _____	% S _____	% S _____
% CaO _____	% CaO _____	% CaO _____	% CaO _____	% CaO _____	% CaO _____

Comments:

DATA SHEET

Date <u>5/20/83</u>		Sorbent Location <u>At Fuel</u>	
Fuel <u>Utah</u>	% S <u>.90</u>	Cooling <u>None</u>	Location <u>N/A</u>
Sorbent <u>Colton Hydrated Ca(OH)₂</u>		Burner <u>Divergent Injector, Internally Staged</u>	

Run #s <u>5/20-13, 5/20-14</u> Load (M Btu/hr) <u>1.03</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.19</u> Ca/S <u>1.0</u>	Run #s <u>5/20-15, 5/20-16</u> Load (M Btu/hr) <u>1.03</u> Air Heat <u>None</u> SRp <u>.20</u> SRB <u>.60</u> SRT <u>1.18</u> Ca/S <u>2.0</u>	Run #s <u>5/20-17, 5/20-18</u> Load (M Btu/hr) <u>1.03</u> Air Heat <u>None</u> SRp <u>.20</u> SRB <u>.60</u> SRT <u>1.18</u> Ca/S <u>4.0</u>
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SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>623</u> <u>629</u> <u>540</u> SO ₂ W <u>609</u> <u>590</u> <u>494</u> % Capt. <u>2.2</u> <u>6.2</u> <u>8.5</u> % Util. <u>2.2</u> <u>6.2</u> <u>8.5</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>612</u> <u>612</u> <u>545</u> SO ₂ W <u>571</u> <u>522</u> <u>432</u> % Capt. <u>6.7</u> <u>14.7</u> <u>20.7</u> % Util. <u>3.35</u> <u>7.35</u> <u>10.35</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>612</u> <u>612</u> <u>545</u> SO ₂ W <u>557</u> <u>435</u> <u>326</u> % Capt. <u>9.0</u> <u>28.9</u> <u>40.18</u> % Util. <u>2.25</u> <u>7.23</u> <u>10.05</u>
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Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2674</u> Exit Rad. <u>2463</u> Exit PFC <u>1805</u> Exit Conv. <u>572</u>	Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2690</u> Exit Rad. <u>2467</u> Exit PFC <u>1809</u> Exit Conv. <u>580</u>	Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2687</u> Exit Rad. <u>2467</u> Exit PFC <u>1814</u> Exit Conv. <u>586</u>
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Solid Samples Location _____ Location _____ # _____ % S _____ % CaO _____	Solid Samples Location _____ Location _____ # _____ % S _____ % CaO _____	Solid Samples Location _____ Location _____ # _____ % S _____ % CaO _____
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Solid Samples Location _____ Location _____ # _____ % S _____ % CaO _____	Solid Samples Location _____ Location _____ # <u>5/20-16-2</u> % S _____ % CaO _____	Solid Samples Location _____ Location _____ # _____ % S _____ % CaO _____
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Comments:

DATA SHEET

Date <u>6/1/83</u>		Sorbent Location <u>At Fuel</u>	
Fuel <u>Illinois 6</u>	% S <u>3.50</u>	Cooling <u>None</u>	Location <u>N/A</u>
Sorbent <u>Dolomite</u>		Burner <u>Divergent Injector, DMB</u>	

Run #s <u>6/1-1, 6/1-2</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.21</u> SRg <u>.59</u> SRT <u>1.18</u> Ca/S <u>1.03</u>	Run #s <u>6/1-3, 6/1-4</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.21</u> SRg <u>.59</u> SRT <u>1.18</u> Ca/S <u>2.06</u>	Run #s <u>6/1-5, 6/1-6</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.21</u> SRg <u>.58</u> SRT <u>1.18</u> Ca/S <u>3.08</u>
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SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.Q. <u>3497</u> <u>3289</u> <u>3231</u> SO ₂ W <u>3198</u> <u>2373</u> <u>2210</u> % Capt. <u>8.6</u> <u>27.9</u> <u>31.6</u> % Util. <u>8.3</u> <u>26.9</u> <u>30.5</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.Q. <u>3565</u> <u>3482</u> <u>3392</u> SO ₂ W <u>2980</u> <u>1414</u> <u>1214</u> % Capt. <u>16.4</u> <u>59.4</u> <u>64.2</u> % Util. <u>7.97</u> <u>28.9</u> <u>31.2</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.Q. <u>3664</u> <u>3545</u> <u>3421</u> SO ₂ W <u>2938</u> <u>890</u> <u>617</u> % Capt. <u>19.8</u> <u>74.9</u> <u>82.0</u> % Util. <u>6.4</u> <u>24.29</u> <u>26.6</u>
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Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2614</u> Exit Rad. <u>2412</u> Exit PFC <u>1730</u> Exit Conv. <u>565</u>	Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2612</u> Exit Rad. <u>2424</u> Exit PFC <u>1729</u> Exit Conv. <u>602</u>	Temperature Measurements Tg1 <u>Center of Radiant 2712</u> Tg2 <u>Horizontal Trans 2494</u> Center Rad. <u>2565</u> Exit Rad. <u>2565</u> Exit PFC <u>1767</u> Exit Conv. <u>654</u>
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Solid Samples Location	Location	Solid Samples Location	Location
# _____	# _____	# <u>6/1-4-2</u>	# _____
% S _____	% S _____	% S _____	% S _____
% CaO _____	% CaO _____	% CaO _____	% CaO _____

Solid Samples Location	Location	Solid Samples Location	Location
# _____	# _____	# _____	# _____
% S _____	% S _____	% S _____	% S _____
% CaO _____	% CaO _____	% CaO _____	% CaO _____

Comments:

F-30

DATA SHEET

Date 6/3/83 Sorbent Location With Fuel
 Fuel Indiana 4 % S 1.40 Cooling None Location N/A
 Sorbent Dolomite Burner Divergent Injector, DMB

Run #s 6/3-7, 6/3-8
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 1.40

Run #s 6/3-9, 6/3-10
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 2.80

Run #s 6/3-11, 6/3-12
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 5.60

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1290 1289 1246
 SO₂ W 1217 1019 951
 % Capt. 5.7 21.0 23.7
 % Util. 4.07 15.0 16.92

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1348 1314 1242
 SO₂ W 1253 582 531
 % Capt. 7.0 55.7 57.24
 % Util. 2.5 19.9 20.44

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1356 1350 1296
 SO₂ W 1234 352 271
 % Capt. 9.0 74.0 79.1
 % Util. 1.60 13.2 14.12

Temperature Measurements

Tg₁ Center of Radiant 2690
 Tg₂ Horizontal Trans. 2533
 Center Rad. 2623
 Exit Rad. 2407
 Exit PFC 1822
 Exit Conv. 606

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2652
 Exit Rad. 2431
 Exit PFC 1815
 Exit Conv. 634

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2557
 Exit Rad. 2437
 Exit PFC 1815
 Exit Conv. 635

Solid Samples

Location	Location
# _____	# _____
% S _____	% S _____
% CaO _____	% CaO _____

Solid Samples

Location	Location
# _____	# <u>6/3-10-2</u>
% S _____	% S _____
% CaO _____	% CaO _____

Solid Samples

Location	Location
# _____	# _____
% S _____	% S _____
% CaO _____	% CaO _____

Comments:

DATA SHEET

Date 6/6/83 Sorbent Location With Fuel
 Fuel Indiana 4 % S 1.40 Cooling None Location N/A
 Sorbent Marble White 125 Burner Divergent Injector, DMB

Run #s 6/6-1, 6/6-2
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .20
 SRB .59
 SRT 1.18
 Ca/S 1.40

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1289 1184 1132
 SO₂ W 1263 1137 1088
 % Capt. 2.7 4.0 4.0
 % Util. 1.92 2.86 2.86

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2633
 Exit Rad. 2429
 Exit PFC 1828
 Exit Conv. 595

Solid Samples

Location	Location
# _____	# _____
% S _____	% S _____
% CaO _____	% CaO _____

Run #s 6/6-3, 6/6-4
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .20
 SRB .59
 SRT 1.18
 Ca/S 2.80

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1298 1186 1141
 SO₂ W 1243 1098 1024
 % Capt. 4.23 7.42 10.25
 % Util. 1.51 2.65 3.66

Temperature Measurements

Tg₁ Center of Radiant 2781
 Tg₂ Horiz. Trans. 2528
 Center Rad. 2635
 Exit Rad. 2435
 Exit PFC 1820
 Exit Conv. 606

Solid Samples

Location	Location
# _____	# <u>6/6-4-2</u>
% S _____	% S _____
% CaO _____	% CaO _____

Run #s 6/6-5, 6/6-6
 Load (M Btu/hr) 1.06
 Air Heat None
 SRp .20
 SRB .59
 SRT 1.18
 Ca/S 5.73

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1353 1287 1232
 SO₂ W 1283 941 850
 % Capt. 5.2 26.9 31.0
 % Util. .9 4.69 5.41

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2654
 Exit Rad. 2454
 Exit PFC 1827
 Exit Conv. 631

Solid Samples

Location	Location
# _____	# _____
% S _____	% S _____
% CaO _____	% CaO _____

Comments:

DATA SHEET

Date <u>6/6/83</u>		Sorbent Location <u>With Fuel</u>	
Fuel <u>Indiana 4</u>	% S <u>1.40</u>	Cooling <u>None</u>	Location <u>N/A</u>
Sorbent <u>Fredonia (coarse)</u>		Burner <u>Divergent Injector, DMB</u>	

Run #s <u>6/6-7, 6/6-8</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.18</u> Ca/S <u>1.41</u>	Run #s <u>6/6-9, 6/6-10</u> Load (M Btu/hr) <u>1.04</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.18</u> Ca/S <u>2.81</u>	Run #s <u>6/6-11, 6/6-12</u> Load (M Btu/hr) <u>1.05</u> Air Heat <u>None</u> SRp <u>.21</u> SRB <u>.61</u> SRT <u>1.18</u> Ca/S <u>5.70</u>
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SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>1349</u> <u>1270</u> <u>1214</u> SO ₂ W <u>1287</u> <u>1189</u> <u>1134</u> % Capt. <u>4.6</u> <u>6.4</u> <u>6.6</u> % Util. <u>3.26</u> <u>4.53</u> <u>4.68</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>1316</u> <u>1231</u> <u>1197</u> SO ₂ W <u>1246</u> <u>1049</u> <u>986</u> % Capt. <u>5.3</u> <u>14.8</u> <u>17.62</u> % Util. <u>1.89</u> <u>5.26</u> <u>6.27</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>1300</u> <u>1242</u> <u>1185</u> SO ₂ W <u>1182</u> <u>656</u> <u>584</u> % Capt. <u>9.1</u> <u>47.2</u> <u>50.7</u> % Util. <u>1.59</u> <u>8.28</u> <u>8.9</u>
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Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2654</u> Exit Rad. <u>2454</u> Exit PFC <u>1800</u> Exit Conv. <u>626</u>	Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2648</u> Exit Rad. <u>2448</u> Exit PFC <u>1801</u> Exit Conv. <u>626</u>	Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2648</u> Exit Rad. <u>2448</u> Exit PFC <u>1801</u> Exit Conv. <u>628</u>
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Solid Samples Location _____ # _____ % S _____ % CaO _____	Solid Samples Location _____ # _____ % S _____ % CaO _____	Solid Samples Location <u>Exit of post-flame</u> # <u>6/6-10-2</u> % S _____ % CaO _____
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Solid Samples Location _____ # _____ % S _____ % CaO _____	Solid Samples Location _____ # _____ % S _____ % CaO _____
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Comments:

DATA SHEET

Date 6/16/83 Sorbent Location With Fuel
 Fuel Indiana 4 % S 1.40 Cooling None Location N/A
 Sorbent Vicron 45-3 Burner Divergent Injector, DMB

Run #s 6/16-1, 6/16-2Load (M Btu/hr) 1.06Air Heat NoneSRp .20SRB .58SRT 1.18Ca/S 1.41Run #s 6/16-3, 6/16-4Load (M Btu/hr) 1.04Air Heat NoneSRp .20SRB .58SRT 1.19Ca/S 2.84Run #s 6/16-5, 6/16-6Load (M Btu/hr) 1.05Air Heat NoneSRp .20SRB .58SRT 1.18Ca/S 5.70SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1190 1156SO₂ W 1054 978% Capt. 11.4 15.4% Util. 8.08 10.92SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1214 1165SO₂ W 756 568% Capt. 37.7 51.2% Util. 13.27 18.03SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 1252 1191SO₂ W 413 262% Capt. 67.0 78.0% Util. 11.75 13.68

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2739Exit Rad. 2460Exit PFC 1810Exit Conv. 589

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2740Exit Rad. 2460Exit PFC 1813Exit Conv. 633

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2739Exit Rad. 2460Exit PFC 1814Exit Conv. 642

Solid Samples

Location Location

 # _____
 % S _____
 % CaO _____

Solid Samples

Location Location
Exit of post-flame
 # 6/16-4-2
 % S _____
 % CaO _____

Solid Samples

Location Location

 # _____
 % S _____
 % CaO _____

Comments:

DATA SHEET

Date 6/16/83 Sorbent Location With Fuel
 Fuel Indiana 4 % S 1.40 Cooling None Location N/A
 Sorbent German Ca(OH)₂ Burner Divergent Injector, DMB

Run #s 6/16-7, 6/16-8
 Load (M Btu/hr) 1.05
 Air Heat None
 SRp .20
 SRg .58
 SRT 1.18
 Ca/S 1.40

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1279 1193
 SO₂ W 1109 986
 % Capt. 13.29 17.35
 % Util. 9.49 12.39

Temperature Measurements

Tg1 _____
 Tg2 _____
 Center Rad. 2780
 Exit Rad. 2452
 Exit PFC 1810
 Exit Conv. 646

Solid Samples
 Location Location

 % S _____
 % CaO _____

Run #s 6/16-9, 6/16-10
 Load (M Btu/hr) 1.05
 Air Heat None
 SRp .20
 SRg .58
 SRT 1.18
 Ca/S 2.82

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1258 1183
 SO₂ W 738 588
 % Capt. 41.33 50.3
 % Util. 14.66 17.8

Temperature Measurements

Tg1 _____
 Tg2 _____
 Center Rad. 2730
 Exit Rad. 2450
 Exit PFC 1811
 Exit Conv. 645

Solid Samples
 Location Location
 Exit of post-flame

6/16-10-2
 % S _____
 % CaO _____

Run #s 6/16-11, 6/16-12
 Load (M Btu/hr) 1.04
 Air Heat None
 SRp .21
 SRg .59
 SRT 1.19
 Ca/S 5.71

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1273 1193
 SO₂ W 315 208
 % Capt. 75.25 82.6
 % Util. 13.17 14.46

Temperature Measurements

Tg1 _____
 Tg2 _____
 Center Rad. 2738
 Exit Rad. 2458
 Exit PFC 1814
 Exit Conv. 652

Solid Samples
 Location Location

 % S _____
 % CaO _____

Comments:

DATA SHEET

Date 6/3/83 Sorbent Location With Fuel
 Fuel Indiana 4 % S 1.40 Cooling None Location N/A
 Sorbent Vicron 45-3 Burner Divergent Injector, DMB

Run #s 6/3-1, 6/3-2
 Load (M Btu/hr) 1.05
 Air Heat None
 SRp .21
 SRB .58
 SRT 1.18
 Ca/S 1.39

Run #s 6/3-3, 6/3-4
 Load (M Btu/hr) 1.05
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 2.85

Run #s 6/5-5, 6/3-6
 Load (M Btu/hr) 1.05
 Air Heat None
 SRp .21
 SRB .60
 SRT 1.18
 Ca/S 5.66

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1395 1313 1278
 SO₂ W 1300 1175 1114
 % Capt. 6.8 10.51 12.83
 % Util. 4.89 7.56 9.23

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1329 1309 1270
 SO₂ W 1224 882 750
 % Capt. 7.9 32.62 40.9
 % Util. 2.81 11.59 14.53

SO₂ Measurements
 Port 1 Port 2 Port 3
 SO₂ W.O. 1288 1359 1272
 SO₂ W 1165 405 284
 % Capt. 9.5 70.2 77.7
 % Util. 1.68 12.4 13.73

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2623
 Exit Rad. 2407
 Exit PFC 1822
 Exit Conv. 606

Temperature Measurements

Tg₁ _____
 Tg₂ _____
 Center Rad. 2634
 Exit Rad. 2414
 Exit PFC 1814
 Exit Conv. 612

Temperature Measurements

Tg₁ Center of Radiant 2690
 Tg₂ Horizontal Trans 2533
 Center Rad. 2643
 Exit Rad. 2425
 Exit PFC 1817
 Exit Conv. 626

Solid Samples

Location	Location
# _____	# _____
% S _____	% S _____
% CaO _____	% CaO _____

Solid Samples

Location	Location
# _____	# <u>6/3-4-2</u>
% S _____	% S _____
% CaO _____	% CaO _____

Solid Samples

Location	Location
# _____	# _____
% S _____	% S _____
% CaO _____	% CaO _____

Comments:

Date AUGUST 3, 1983Sorbent Location AT POST FLAME CAVITYFuel INDIANA L 3 % S 1.29 Cooling NONE Location N.ASorbent VICRON 45-3 Burner DIVERGENT INJECTOR, D.M.BRun #s 8-3-1, 8-3-2Load (M Btu/hr) 1.05Air Heat NONESRp 0.15SRB 0.59SRT 0.93, SRTOTAL 1.25Ca/S 0.944Run #s 8-3-3, 8-3-4Load (M Btu/hr) 1.05Air Heat NONESRp 0.15SRB 0.59SRT 0.96, SRTOT 1.25Ca/S 1.89Run #s 8-3-5, 8-3-6Load (M Btu/hr) 1.04Air Heat NONESRp 0.15SRB 0.60SRT 0.97, SRTOT 1.26Ca/S 3.74SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1267 1147 1120SO₂ W 1238 993 944% Capt. 2.3 13.42 15.7% Util. 2.43 14.2 16.6SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1233 1115 1073SO₂ W 1073 756 676% Capt. 13 32.2 373% Util. 6.87 17.0 19.7SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1085 895 868SO₂ W 855 376 292% Capt. 21.2 58. 66.4% Util. 5.66 15.15 17.8

Temperature Measurements

Tg1

Tg2

Center Rad. 2717.Exit Rad. 2591.Exit PFC 1630Exit Conv. 535

Temperature Measurements

Tg1 CENTER OF RADIANT 2780.Tg2 SORBENT INJECTOR 2100Center Rad. 2717.Exit Rad. 2590.Exit PFC 1630.Exit Conv. 535

Temperature Measurements

Tg1

Tg2

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-3-4-2

% S _____

% CaO _____

8-3-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

Date AUGUST 3-83Sorbent Location AT POST FLAME CAVITYFuel INDIANA L3% S 1.12Cooling NONELocation N.ASorbent COLTON HYDRATEL Ca(OH)_2 Burner DIVERGENT INJECTOR, D.M.B.Run #s 8-3-9, 8-3-10Load (M Btu/hr) 1.00Air Heat NONESRp 0.15SRg 0.59SRT 0.96, SRTOT 1.25Ca/S 1.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1044 876 856SO₂ W 281 761 731% Capt. 6 10.84 14.6% Util. 6 10.84 14.6Run #s 8-3-11, 8-3-12Load (M Btu/hr) 1.00Air Heat NONESRp 0.15SRg 0.59SRT 0.96, SRTOTAL 1.25Ca/S 1.99SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1027 934 905SO₂ W 737 582 527% Capt. 28.2 37.68 41.8% Util. 14.2 18.9 21.Run #s 8-3-13, 8-3-14Load (M Btu/hr) 1.0Air Heat NONESRp 0.15SRg 0.59SRT 0.96, SRTOT 1.25Ca/S 3.99SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1098 999 966SO₂ W 796 336 248% Capt. 27.5 66.36 74.32% Util. 6.9 16.6 18.7

Temperature Measurements

Tg1

Tg2 SORBENT INJECTOR 2100.Center Rad. 2710.Exit Rad. 2590.Exit PFC 1650.Exit Conv. 594.

Temperature Measurements

Tg1 CENTER OF RADIANT 2780.Tg2 EXIT OF POST FLAME 1800.Center Rad. 2709.Exit Rad. 2590.Exit PFC 1655.Exit Conv. 600.

Temperature Measurements

Tg1

Tg2

Center Rad. 2700.Exit Rad. 2600.Exit PFC 1670.Exit Conv. 610.

Solid Samples

Location

Location

#

% S

% CaO

Solid Samples

Location

Location

EXIT OF POST FLAME

EXIT OF CONV

8-3-12-2

% S

% CaO

8-3-12-3

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

Date AUGUST 4, 1983Sorbent Location AT POST FLAME CAVITYFuel INDIANA 13% S 1.18Cooling NONELocation N.ASorbent DOLOMITEBurner DIVERGENT INJECTOR, D.M.B.Run #s 8-4-5, 8-4-6Load (M Btu/hr) 1.02Air Heat NONESRp 0.16SRB 0.59SRT 0.95, SRTOT 1.25Ca/S 1.0Run #s 8-4-7, 8-4-8Load (M Btu/hr) 1.02Air Heat NONESRp 0.16SRB 0.60SRT 0.95, SRTOT 1.25Ca/S 2.0

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1083 946 904SO₂ W 318 353 313% Capt. 24.5 62.7 65.4% Util. 24.5 62.7 65.4SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1116 985 944SO₂ W 797 201 136% Capt. 28.6 79.6 85.6% Util. 14.3 39.8 42.6SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2700.Exit Rad. 2600.Exit PFC 1660.Exit Conv. 628.

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2700.Exit Rad. 2601Exit PFC 1660Exit Conv. 628

Temperature Measurements

Tg₁ _____Tg₂ _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C.

EXIT OF CONV

8-4-8-2

% S _____

% CaO _____

8-4-8-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

Date AUGUST 2, 1983Sorbent Location AT POST FLAME CAVITYFuel INDIANA L3% S 1.29Cooling NONELocation N.ASorbent FREDONIA (COARSE)Burner DIVERGENT INJECTOR, D.M.BRun #s 8-2-5, 8-2-6Load (M Btu/hr) 1.02Air Heat NONESRp 0.14SRB 0.59SRT 0.95, SRTOT 1.25Ca/S 0.93Run #s 8-2-7, 8-2-8Load (M Btu/hr) 1.02Air Heat NONESRp 0.14SRB 0.59SRT 0.95, SRTOT 1.25Ca/S 1.87

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1240 1108 1045SO₂ W 1111 829 760% Capt. 10.4 25.18 27.27% Util. 11.2 27.0 29.3SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1240 1121 1065SO₂ W 996 604 548% Capt. 19.67 46.12 48.54% Util. 10.5 24.7 25.9SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2748.Exit Rad. 2622Exit PFC 1661Exit Conv. 666

Temperature Measurements

Tg₁ _____Tg₂ _____Center Rad. 2748.Exit Rad. 2622Exit PFC 1661Exit Conv. 666

Temperature Measurements

Tg₁ _____Tg₂ _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-2-8-2

% S _____

% CaO _____

8-2-8-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

Date AUGUST 24, 1983Sorbent Location AT POST FLAME CAVITYFuel NATURAL - H₂S % S _____ Cooling NONE Location N.ASorbent VICRON 45-3 Burner RADIAL INJECTOR, D.M.B.Run #s 7-24-1, 7-24-2Load (M Btu/hr) 1.05Air Heat NONESRp 0.00SRB 0.60SRT 1.12, SRTOT 1.45

Ca/S _____

Run #s 7-24-3, 7-24-4Load (M Btu/hr) 1.05Air Heat NONESRp 0.0SRB 0.60SRT 1.13, SRTOT 1.45Ca/S 3.00

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2057 1915 1775SO₂ W 1793 1316 1166% Capt. 12.8 31.28 34.3% Util. 8.6 21.13 23.1SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2085 1935 1827SO₂ W 1692 929 646% Capt. 19.0 52 64.6% Util. 6.3 17.3 21.53SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2703Exit Rad. 2656Exit PFC 1720Exit Conv. 705

Temperature Measurements

Tg1 SORBENT INJECTOR 2032

Tg2 _____

Center Rad. 2700Exit Rad. 2650Exit PFC 1703Exit Conv. 698

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

7-24-4-2

% S _____

% CaO _____

7-24-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

LOAD 1.04 MBTU/hr, HIGH OXIDANT AND HIGH OXYGEN
PERCENT IN FLARE GAS.

Date AUGUST 2, 1983Sorbent Location AT POST FLAME CAVITYFuel NATURAL - H₂S % S _____Cooling NONE Location N.ASorbent DOLOMITEBurner RADIAL INJECTOR, D. M. BRun #s 8-2-1, 8-2-2Load (M Btu/hr) 1.03Air Heat NONESRp 0.0SRB 0.59SRT 0.95, SRTOTAL 1.25Ca/S 0.985SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.O.	2230	1961	1905
SO ₂ W	1929	1013	857

% Capt. 13.49 48.3 55.% Util. 13.70 49. 55.8Run #s 8-2-3, 8-2-4Load (M Btu/hr) 1.02Air Heat NONESRp 0.0SRB 0.59SRT 0.95, SRTOTAL 1.25Ca/S 2.0SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.O.	2139	1960	1864
SO ₂ W	1528	467	308

% Capt. 28.6 76.17 82.8% Util. 14.3 38.1 41.4

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2737.Exit Rad. 2701.Exit PFC 1690Exit Conv. 664

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2736.Exit Rad. 2701.Exit PFC 1691.Exit Conv. 665.

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF PFC

EXIT OF CONV

8-2-4-2

% S _____

% CaO _____

8-2-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

Date AUGUST 16-83Sorbent Location AT POST FLAME CAVITYFuel NATURAL - H₂S % S _____ Cooling NONE Location N.A.Sorbent FREDONIA (COARSE) Burner RADIANT INJECTOR, D.M.B.Run #s 8-16-1, 8-16-2Load (M Btu/hr) 1.02Air Heat NONESRp 0.00SRB 0.59SRT 0.95, SRTOTAL 1.24Ca/S 1.01Run #s 8-16-3, 8-16-4Load (M Btu/hr) 1.02Air Heat NONESRp 0.0SRB 0.59SRT 0.95, SRTOTAL 1.25Ca/S 1.97Run #s 8-16-5, 8-16-6Load (M Btu/hr) 1.02Air Heat NONESRp 0.0SRB 0.59SRT 0.95, SRTOT 1.24Ca/S 3.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2099 1860 1744SO₂ W 1858 1470 1285% Capt. 11.5 21.3 26.3% Util. 11.5 21.3 26.3SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2060 1858 1752SO₂ W 1797 1316 1120% Capt. 12.8 29.2 36.0% Util. 6.5 14.8 18.3SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2113 1919 1848SO₂ W 1708 994 738% Capt. 19.2 48.2 60.1% Util. 6.4 16.1 20.0

Temperature Measurements

Tg1 CENTER OF RADIANT 2827Tg2 SORBENT INJECTOR 2083Center Rad. 2696Exit Rad. 2585Exit PFC 1638Exit Conv. 608

Temperature Measurements

Tg1 _____

Tg2 EXIT OF POSTFLAME 1740Center Rad. 2696Exit Rad. 2586Exit PFC 1639Exit Conv. 607

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2700Exit Rad. 2596Exit PFC 1640Exit Conv. 610

Solid Samples

Location

Location

% S
% CaO#
% S
% CaO

Solid Samples

Location

Location

8-16-4-2
% S
% CaO# 8-16-4-3
% S
% CaO

Solid Samples

Location

Location

% S
% CaO#
% S
% CaO

Comments:

Date July 22, 1983Sorbent Location At Post flame cavityFuel Natural - H₂S % S _____ Cooling None Location N.ASorbent Colton hydrated Ca(OH)₂ Burner Radial injector, D.M.BRun #s 7-22-1, 7-22-2Load (M Btu/hr) 1.05Air Heat NoneSRp 0.0SRg 0.60SRT 0.93, SRTOT 1.21Ca/S 0.99SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1920 1867 1818SO₂ W 1810 1605 1460% Capt. 5.7 14 19.7% Util. 5.75 14.1 19.9Run #s 7-22-3, 7-22-4Load (M Btu/hr) 1.04Air Heat NoneSRp 0.0SRg 0.61SRT 0.93, SRTOT 1.21Ca/S 1.99SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1953 1850 1830SO₂ W 1585 1289 1083% Capt. 18.8 30.32 40.8% Util. 9.4 15.2 20.5Run #s 7-22-5, 7-22-6Load (M Btu/hr) 1.02Air Heat NoneSRp 0.0SRg 0.61SRT 0.94, SRTOT 1.21Ca/S 3.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1923 1895 1823SO₂ W 1484 600 492% Capt. 22.8 68.3 73.0% Util. 7.6 22.8 24.3

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2715Exit Rad. 2709Exit PFC 1695Exit Conv. 559

Temperature Measurements

Tg1 Center of Radiant 2958Tg2 Sorbent injector 2125Center Rad. 2715Exit Rad. 2709Exit PFC 1686Exit Conv. 571

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2716Exit Rad. 2709Exit PFC 1686Exit Conv. 575

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

7-22-4-2

% S _____

% CaO _____

7-22-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

Date AGUST 13, 1983Sorbent Location AT POST FLAME CAVITYFuel INDIANA L 5 % S 2.32 Cooling NONE Location N.ASorbent VICRON 45-3 Burner DIVERGENT INJECTOR, D.M.B

Run #s <u>8-13-1, 8-13-2</u> Load (M Btu/hr) <u>1.07</u> Air Heat <u>NONE</u> SRp <u>0.18</u> SRB <u>0.60</u> SRT <u>0.95, SRTOT 1.24</u> Ca/S <u>0.988</u>	Run #s <u>8-13-3, 8-13-4</u> Load (M Btu/hr) <u>1.07</u> Air Heat <u>NONE</u> SRp <u>0.18</u> SRB <u>0.61</u> SRT <u>0.95, SRTOT 1.25</u> Ca/S <u>2.01</u>	Run #s <u>8-13-5, 8-13-6</u> Load (M Btu/hr) <u>1.07</u> Air Heat <u>NONE</u> SRp <u>0.18</u> SRB <u>0.61</u> SRT <u>0.95, SRTOT 1.25</u> Ca/S <u>3.0</u>
SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>2121</u> <u>1903</u> <u>1851</u> SO ₂ W <u>2018</u> <u>1593</u> <u>1487</u> % Capt. <u>4.9</u> <u>16.3</u> <u>19.7</u> % Util. <u>5.0</u> <u>16.5</u> <u>20.0</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>2046</u> <u>1857</u> <u>1783</u> SO ₂ W <u>1811</u> <u>1107</u> <u>953</u> % Capt. <u>11.4</u> <u>40.</u> <u>46.5</u> % Util. <u>5.7</u> <u>20</u> <u>23.3</u>	SO ₂ Measurements Port 1 Port 2 Port 3 SO ₂ W.O. <u>2140</u> <u>1849</u> <u>1796</u> SO ₂ W <u>1680</u> <u>936</u> <u>752</u> % Capt. <u>21.5</u> <u>49.4</u> <u>58.0</u> % Util. <u>7.2</u> <u>16.5</u> <u>19.3</u>
Temperature Measurements Tg1 _____ Tg2 <u>SORBENT INJECTOR 2113</u> Center Rad. <u>2692</u> Exit Rad. <u>2552</u> Exit PFC <u>1548</u> Exit Conv. <u>505</u>	Temperature Measurements Tg1 <u>CENTER OF RADIANT 2701</u> Tg2 <u>EXIT OF POST FLAME 1647</u> Center Rad. <u>2690.</u> Exit Rad. <u>2554.</u> Exit PFC <u>1550.</u> Exit Conv. <u>509.</u>	Temperature Measurements Tg1 _____ Tg2 _____ Center Rad. <u>2690</u> Exit Rad. <u>2552</u> Exit PFC <u>1551</u> Exit Conv. <u>510</u>
Solid Samples Location Location # _____ # _____ % S _____ % S _____ % CaO _____ % CaO _____	Solid Samples Location Location EXIT OF P.F.C EXIT OF CONV # <u>8-13-4-2</u> # <u>8-13-4-3</u> % S _____ % S _____ % CaO _____ % CaO _____	Solid Samples Location Location # _____ # _____ % S _____ % S _____ % CaO _____ % CaO _____

Comments:

Date AUGUST 15, 1983Sorbent Location AT POST FLAME CAVITYFuel INDIANA L 3 % S 2.48 Cooling NONE Location N.ASorbent COLTON HYDRATED $\text{Ca}(\text{OH})_2$ Burner DIVERGENT INJECTOR, D.M.BRun #s 8-15-1, 8-15-2Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRB 0.60SRT 0.95, SRTOT 1.25Ca/S 0.89Run #s 8-15-3, 8-15-4Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRB 0.61SRT 0.95, SRTOT 1.25Ca/S 1.77Run #s 8-15-5, 8-15-6Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRB 0.61SRT 0.95, SRTOT 1.25Ca/S 2.71SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.Q	2092	1890	1803
SO ₂ W	1882	1433	1304

% Capt.	10.	24.2	27.7
---------	-----	------	------

% Util.	11.23	27.2	31.12
---------	-------	------	-------

SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.Q	2155.	2003.	1922.
SO ₂ W	1776.	1106	875.

% Capt.	17.6	44.8	54.5
---------	------	------	------

% Util.	9.94	25.3	30.8
---------	------	------	------

SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.Q	2092	1966	1878.
SO ₂ W	1156	592	380.

% Capt.	44.9	69.9	79.8
---------	------	------	------

% Util.	16.6	25.79	29.44
---------	------	-------	-------

Temperature Measurements

Tg1

Tg2

Center Rad. 2701.Exit Rad. 2560.Exit PFC 1565.Exit Conv. 532.

Temperature Measurements

Tg1

Tg2

Center Rad. 2702.Exit Rad. 2560.Exit PFC 1565.Exit Conv. 533.

Temperature Measurements

Tg1

Tg2

Center Rad. 2700.Exit Rad. 2562.Exit PFC 1570.Exit Conv. 537.

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-15-4-2

% S

% CaO

8-15-4-3

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

Date AUGUST 13, 1983Sorbent Location AT POST FLAME CAVITYFuel INDIANA L5% S 2.25Cooling NONELocation N.ASorbent DOLOMITEBurner DIVERGENT INJECTOR, D.M.BRun #s 8-13-7, 8-13-8Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRg 0.61SRT 0.95, SRTOT 1.25Ca/S 1.0Run #s 8-13-9, 8-13-10Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRg 0.60SRT 0.94, SRTOT 1.24Ca/S 2.02

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRg _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2188 1858 1777SO₂ W 1863 1052 896% Capt. 14.85 43.4 49.6% Util. 14.85 43.4 49.6SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2204 1965 1875SO₂ W 1521 630 471% Capt. 31.0 68.0 74.9% Util. 15.3 33.7 37.1SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 CENTER OF RADIANT 2701Tg2 SORBENT INJECTOR 2113Center Rad. 2690Exit Rad. 2554Exit PFC 1556Exit Conv. 512

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2692Exit Rad. 2558Exit PFC 1560Exit Conv. 532

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-13-10-2

% S _____

% CaO _____

8-13-10-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

Date AUGUST 15-83Sorbent Location AT POST FLAME CAVITYFuel INDIANA L-5 % S 2.32 Cooling NONE Location N.ASorbent FREDONIA (COARSE) Burner DIVERGENT INJECTOR, D.M.B.Run #s 8-15-7, 8-15-8Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRB 0.60SRT 0.95, SRTOT 1.25Ca/S 0.936SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2113 1988 1865SO₂ W 1864 1467 1432% Capt. 11.8 26.2 28.6% Util. 12.6 28. 30.6Run #s 8-15-9, 8-15-10Load (M Btu/hr) 1.04Air Heat NONESRp 0.17SRB 0.61SRT 0.95, SRTOT 1.25Ca/S 1.89SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 2067 1913 1833SO₂ W 1654 1180 1013% Capt. 20.0 38.3 44.73% Util. 10.6 20.26 23.7Run #s 8-15-11, 8-15-12Load (M Btu/hr) 1.04Air Heat NONESRp 0.17SRB 0.61SRT 0.95, SRTOT 1.25Ca/S 2.8SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 1925 1868SO₂ W 830 546% Capt. 56.88 70.71% Util. 20.31 25.25

Temperature Measurements

Tg1 Tg2 Center Rad. 2700.Exit Rad. 2555Exit PFC 1565Exit Conv. 532

Temperature Measurements

Tg1 Tg2 Center Rad. 2700.Exit Rad. 2555Exit PFC 1565Exit Conv. 532

Temperature Measurements

Tg1 Tg2 Center Rad. 2700.Exit Rad. 2565Exit PFC 1565Exit Conv. 532

Solid Samples

Location

Location

% S % CaO

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-15-10-2% S % CaO # 8-15-10-3% S % CaO

Solid Samples

Location

Location

% S % CaO # % S % CaO

Comments:

Date AUGUST 23, 1983Sorbent Location AT POST FLAME CAVITYFuel ILLINOIS 6 % S 3.81 Cooling NONE Location N.ASorbent FREDONIA (COARSE) Burner DIVERGENT INJECTOR, D.M.BRun #s 8-23-1, 8-23-2Load (M Btu/hr) 1.03Air Heat NONESRp 0.16SRB 0.59SRT 0.95, SRTOTAL 1.25Ca/S 1.0Run #s 8-23-3, 8-23-4Load (M Btu/hr) 1.04Air Heat NONESRp 0.17SRB 0.60SRT 0.94, SRTOTAL 1.25Ca/S 1.38

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 3324 2980 2889SO₂ W 2971 2354 2153% Capt. 10.6 21.0 25.5% Util. 10.6 21.0 25.7SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 3434 3185 3123SO₂ W 2634 1826 1452% Capt. 21.5 42.7 53.5% Util. 10.8 21.6 27.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 SORBENT INJECTOR 2046Tg2 EXIT OF POST FLAME 1777Center Rad. 2696Exit Rad. 2660Exit PFC 1649Exit Conv. 622

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2700Exit Rad. 2661Exit PFC 1648Exit Conv. 621

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-23-4-2

% S _____

% CaO _____

8-23-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

Date AUGUST 22, 1983Sorbent Location AT POST FLAME CAVITYFuel ILLINOIS 6 % S 3.81 Cooling NONE Location N.ASorbent COLTON HYDRATED $\text{Ca}(\text{OH})_2$ Burner DIVERGENT INJECTOR, D.M.BRun #s 8-22-1, 8-22-2Load (M Btu/hr) 1.01Air Heat NONESRp 0.16SRB 0.59SRT 0.95, SRTOT 1.25Ca/S 0.96Run #s 8-22-3, 8-22-4Load (M Btu/hr) 1.02Air Heat NONESRp 0.16SRB 0.60SRT 0.95, SRTOT 1.25Ca/S 1.90

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.O.	3310	3099	3055
SO ₂ W	3199	2635	2434

% Capt.	3.40	15	20.3
---------	------	----	------

% Util.	3.54	15.62	21.14
---------	------	-------	-------

SO₂ Measurements

Port 1 Port 2 Port 3

SO ₂ W.O.	3352	3109	3071
SO ₂ W	2851	1470	1177

% Capt.	14.8	52.7	61.7
---------	------	------	------

% Util.	7.8	27.7	32.5
---------	-----	------	------

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O.SO₂ W

% Capt.

% Util.

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2671.Exit Rad. 2617Exit PFC 1622Exit Conv. 577

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2675.Exit Rad. 2618.Exit PFC 1628Exit Conv. 578

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

#	% S	% CaO
_____	_____	_____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-22-4-2

% S

% CaO

8-22-4-3

% S

% CaO

Solid Samples

Location

Location

#	% S	% CaO
_____	_____	_____

#	% S	% CaO
_____	_____	_____

Comments:

Date AUGUST 17, 1983Sorbent Location AT POST FLAME CAVITYFuel ILLINOIS 6% S 3.79Cooling NONELocation N.ASorbent VICRON 45-3Burner DIVERGENT INJECTOR, D.M.BRun #s 8-17-1, 8-17-2Load (M Btu/hr) 1.00Air Heat NONESRp 0.18SRg 0.60SRT 0.95, SRTOT 1.25Ca/S 0.96Run #s 8-17-3, 8-17-4Load (M Btu/hr) 1.00Air Heat NONESRp 0.18SRg 0.60SRT 0.95, SRTOT 1.25Ca/S 1.93

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRg _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 3165 2914 2850SO₂ W 3024 2418 2189% Capt. 4.5 17 23.2% Util. 4.7 17.7 24.16SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 3488 3181 3084SO₂ W 2824 1781 1476% Capt. 19.04 44.0 52.14% Util. 9.86 22.8 27.0SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2629Exit Rad. 2559Exit PFC 1640Exit Conv. 585

Temperature Measurements

Tg1 CENTER OF RADIANT 2797.Tg2 SORBENT INJECTOR 2011.Center Rad. 2630Exit Rad. 2562Exit PFC 1640Exit Conv. 595

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF POST FLAME

EXIT OF CONV

8-17-4-2

% S _____

% CaO _____

8-17-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

Date AUGUST 17-1983Sorbent Location AT POST FLAME CAVITYFuel ILLINOIS 6 % S 3.71 Cooling NONE Location N.ASorbent DOLOMITE Burner DIVERGENT INJECTOR, D.M.BRun #s 8-17-5, 8-17-6Load (M Btu/hr) 1.0Air Heat NONESRp 0.17SRg 0.61SRT 0.95, SRTOT 1.25Ca/S 1.03Run #s 8-17-7, 8-17-8Load (M Btu/hr) 1.0Air Heat NONESRp 0.17SRg 0.61SRT 0.96, SRTOT 1.25Ca/S 1.55

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRg _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 3438 3076 2999SO₂ W 2719 1640 1353% Capt. 21.0 46.7 54.9% Util. 20.4 45.3 53.3SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 3402 3086 2939SO₂ W 2369 1127 875% Capt. 30.4 63.5 70.2% Util. 19.6 41.0 45.3SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2630Exit Rad. 2562Exit PFC 1639Exit Conv. 596

Temperature Measurements

Tg1 _____

Tg2 _____

SORBENT INJECTOR 2011

Center Rad. 2630Exit Rad. 2562Exit PFC 1639Exit Conv. 597

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-17-8-2

% S _____

% CaO _____

8-17-8-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

Date AUGUST 5, 1983Sorbent Location AT POST FLAME CAVITYFuel SARR% S 0.80Cooling NONELocation N.ASorbent VICRON 45-3Burner DIVERGENT INJECTOR, D.M.BRun #s 8-5-5, 8-5-6Load (M Btu/hr) 1.01Air Heat NONESRp 0.16SRB 0.60SRT 0.95, SRTOT 1.25Ca/S 0.93Run #s 8-5-7, 8-5-8Load (M Btu/hr) 1.01Air Heat NONESRp 0.16SRB 0.60SRT 0.95, SRTOT 1.25Ca/S 1.90Run #s 8-5-9, 8-5-10Load (M Btu/hr) 1.01Air Heat NONESRp 0.16SRB 0.60SRT 0.95, SRTOT 1.25Ca/S 3.79SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 759 700. 664SO₂ W 710 610. 559% Capt. 6.4 12.9 15.8% Util. 6.9 13.9 16.99SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 756 708 672SO₂ W 667 492 431% Capt. 11.7 30.5 35.9% Util. 6.16 16.05 18.9SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 736 677 637SO₂ W 572 276 175% Capt. 22.2 59.3 72.5% Util. 5.85 15.64 19.12

Temperature Measurements

Tg1

Tg2

Center Rad. 2701Exit Rad. 2609Exit PFC 1623Exit Conv. 576

Temperature Measurements

Tg1 CENTER OF RADIANT 2874.Tg2 EXIT OF POST FLAME 1801Center Rad. 2705.Exit Rad. 2610.Exit PFC 1634.Exit Conv. 578.

Temperature Measurements

Tg1

Tg2

Center Rad. 2748.Exit Rad. 2646.Exit PFC 1660.Exit Conv. 585

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-5-8-2

% S

% CaO

8-5-8-3

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

Date AUGUST 5, 1983Sorbent Location AT POST FLAME CAVITYFuel SARR% S 0.80Cooling NONELocation N.ASorbent DOLOMITEBurner DIVERGENT INJECTOR, D.M.B.Run #s 8-5-1, 8-5-2Load (M Btu/hr) 1.02Air Heat NONESRp 0.16SRg 0.60SRT 0.94, SRTOT 1.25Ca/S 0.92Run #s 8-5-3, 8-5-4Load (M Btu/hr) 1.03Air Heat NONESRp 0.16SRg 0.60SRT 0.94, SRTOT 1.25Ca/S 1.88

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRg _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 751 669 655SO₂ W 675 438 378% Capt. 10.1 34.5 42.3% Util. 11.0 37.5 46.SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 769 680 655SO₂ W 602 279 205% Capt. 21.7 59.0 68.7% Util. 11.54 31.38 36.54SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 _____

Tg2 SORBENT INJECTOR 2157Center Rad. 2700.Exit Rad. 2616Exit PFC 1613Exit Conv. 565

Temperature Measurements

Tg1 CENTER OF RADIANT 2874Tg2 EXIT OF POST FLAME 1800Center Rad. 2701Exit Rad. 2609Exit PFC 1625Exit Conv. 572

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-5-4-2

% S _____

% CaO _____

8-5-4-3

% S _____

% CaO _____

Solid Samples

Location

Location

#

% S _____

% CaO _____

#

% S _____

% CaO _____

Comments:

Date AUGUST 12, 1983Sorbent Location AT POST FLAME CAVITYFuel UTAH% S 0.90Cooling NONELocation N.ASorbent VICRON 45-3Burner DIVERGENT INJECTOR, D. M. BRun #s 8-12-1, 8-12-2Load (M Btu/hr) 1.05Air Heat NONESRp 0.16SRg 0.59SRT 0.95, SRTOT 1.25Ca/S 1.16Run #s 8-12-3, 8-12-4Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRg 0.61SRT 0.95, SRTOT 1.25Ca/S 2.36Run #s 8-12-5, 8-12-6Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRg 0.61SRT 0.95, SRTOT 1.25Ca/S 4.64SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 655 576 545SO₂ W 615 504 432% Capt. 6.1 12.5 20.7% Util. 5.25 10.8 17.8SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 731 653 604SO₂ W 662 506 422% Capt. 9.4 22.5 30.2% Util. 4.0 9.53 12.8SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.O. 719 601 562SO₂ W 605 247 194% Capt. 15.9 58.9 65.6% Util. 3.56 13.2 14.7

Temperature Measurements

Tg1

Tg2

Center Rad. 2655.Exit Rad. 2611Exit PFC 1638Exit Conv. 504

Temperature Measurements

Tg1

Tg2 SORBENT INJECTOR 2136.Center Rad. 2655.Exit Rad. 2611.Exit PFC 1640.Exit Conv. 506.

Temperature Measurements

Tg1

Tg2

Center Rad. 2658.Exit Rad. 2613.Exit PFC 1648.Exit Conv. 512

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-12-4-2

% S

% CaO

8-12-4-3

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

Date AUGUST 12, 1983Sorbent Location AT POST FLAME CAVITYFuel UTAH % S 0.81 Cooling NONE Location N.ASorbent COLTON HYDRATED Ca(OH)₂ Burner DIVERGENT INJECTOR, D.M.BRun #s 8-12-11, 8-12-12Load (M Btu/hr) 1.04Air Heat NONESRp 0.17SRg 0.61SRT 0.95, SRTOTAL 1.25Ca/S 1.20SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 728 615 561SO₂ W 686 523 458% Capt. 5.8 15. 18.4% Util. 4.8 12.5 15.3Run #s 8-12-13, 8-12-14Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRg 0.61SRT 0.94, SRTOT 1.24Ca/S 2.38SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 714 622 577SO₂ W 558 288 223% Capt. 21.84 537 61.4% Util. 9.17 22.5 25.8

Run #s

Load (M Btu/hr)

Air Heat

SRp

SRg

SRT

Ca/S

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q.SO₂ W

% Capt.

% Util.

Temperature Measurements

Tg1

Tg2

Center Rad. 2680Exit Rad. 2622Exit PFC 1622Exit Conv. 539

Temperature Measurements

Tg1

Tg2

SORBENT INJECTOR 2136Center Rad. 2681Exit Rad. 2623Exit PFC 1624Exit Conv. 540

Temperature Measurements

Tg1

Tg2

Center Rad.

Exit Rad.

Exit PFC

Exit Conv.

Solid Samples

Location

Location

#

% S

% CaO

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-12-14-2

% S

% CaO

8-12-14-3

% S

% CaO

Solid Samples

Location

Location

#

% S

% CaO

#

% S

% CaO

Comments:

Date AUGUST 12, 1983Sorbent Location AT POST FLAME CAVITYFuel UTAH % S 0.90 Cooling NONE Location N.ASorbent DOLOMITE Burner DIVERGENT INJECTOR, D.M.BRun #s 8-12-7, 8-12-8Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRB 0.61SRT 0.95, SRTOT 1.25Ca/S 1.18Run #s 8-12-9, 8-12-10Load (M Btu/hr) 1.05Air Heat NONESRp 0.17SRB 0.61SRT 0.95, SRTOT 1.25Ca/S 2.37

Run #s _____

Load (M Btu/hr) _____

Air Heat _____

SRp _____

SRB _____

SRT _____

Ca/S _____

SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 736 617 572SO₂ W 597 330 262% Capt. 18.9 46.5 54.2% Util. 16. 39.4 45.9SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. 732 610 573SO₂ W 531 208 140% Capt. 27.5 65.9 75.6% Util. 11.6 27.8 31.9SO₂ Measurements

Port 1 Port 2 Port 3

SO₂ W.Q. _____SO₂ W _____

% Capt. _____

% Util. _____

Temperature Measurements

Tg1 _____

Tg2 SORBENT INJECTOR 2136Center Rad. 2658Exit Rad. 2613Exit PFC 1648Exit Conv. 513

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. 2689Exit Rad. 2622Exit PFC 1650Exit Conv. 519

Temperature Measurements

Tg1 _____

Tg2 _____

Center Rad. _____

Exit Rad. _____

Exit PFC _____

Exit Conv. _____

Solid Samples

Location

Location

% S _____

% CaO _____

Solid Samples

Location

Location

EXIT OF P.F.C

EXIT OF CONV

8-12-10-2

% S _____

% CaO _____

8-12-10-3

% S _____

% CaO _____

Solid Samples

Location

Location

% S _____

% CaO _____

% S _____

% CaO _____

Comments:

APPENDIX G--PORE MODEL LISTING

01234567890123456789
01234567890123456789
01234567890123456789
01234567890123456789

7-NOV-83 15:26:37 DK2 [2,101]JFOREEPA LST,1
7-NOV-83 15:26:37 DK2 [2,101]JFOREEPA LST,1
7-NOV-83 15:26:37 DK2 [2,101]JFOREEPA LST,1

7-NOV-83 15:26:37
7-NOV-83 15:26:37
7-NOV-83 15:26:37

7-NOV-83 15:26:37
7-NOV-83 15:26:37
7-NOV-83 15:26:37

** RSX-11M V3.2 **
** RSX-11M V3.2 **
** RSX-11M V3.2 **

01234567890123456789
01234567890123456789
01234567890123456789
01234567890123456789

PPPPPPPP 000000 RRRRRRRR EEEEEEEEEE EEEEEEEEEE PPPPPPPP AAAAAA
PPPPPPPP 000000 RRRRRRRR EEEEEEEEEE EEEEEEEEEE PPPPPPPP AAAAAA
PP PP 00 RR RR RR RR PP PP AA AA
PP PP 00 RR RR RR RR PP PP AA AA
PP PP 00 RR RR RR RR PP PP AA AA
PPPPPPPP 00 00 RRRRRRRR EEEEEEEEEE PPPPPPPP AA AA
PPPPPPPP 00 00 RRRRRRRR EEEEEEEEEE PPPPPPPP AA AA
PP PP 00 00 RR RR RR RR EEEEEEEEEE PP AAAAAAAA
PP PP 00 00 RR RR RR RR EEEEEEEEEE PP AA
PP PP 00 00 RR RR RR RR EEEEEEEEEE PP AA
PP PP 000000 RR RR RR EEEEEEEEEE PP AA
PP 000000 RR RR EEEEEEEEEE PP AA
PP 000000 RR EEEEEEEEEE PP AA

G-1

LL SSSSSSSS TTTTTTTTTT 11
LL SSSSSSSS TTTTTTTTTT 11
LL SS TTTTTTTTTT 1111
LL SS TTTTTTTTTT 1111
LL SS TTTTTTTTTT 11
LL SSSSSS TTTTTTTTTT 11
LL SSSSSS TTTTTTTTTT 11
LL SS TTTTTTTTTT 11
LL SS TTTTTTTTTT 11
LL SS TTTTTTTTTT 11
LL SSSSSSSS TTTTTTTTTT 111111
LL SSSSSSSS TTTTTTTTTT 111111

01234567890123456789
01234567890123456789
01234567890123456789
01234567890123456789

7-NOV-83 15:26:37 DK2 [2,101]JFOREEPA LST,1
7-NOV-83 15:26:37 DK2 [2,101]JFOREEPA LST,1
7-NOV-83 15:26:37 DK2 [2,101]JFOREEPA LST,1

7-NOV-83 15:26:37
7-NOV-83 15:26:37
7-NOV-83 15:26:37

7-NOV-83 15:26:37
7-NOV-83 15:26:37
7-NOV-83 15:26:37

** RSX-11M V3.2 **
** RSX-11M V3.2 **
** RSX-11M V3.2 **

01234567890123456789
01234567890123456789
01234567890123456789
01234567890123456789

PORE

ENERGY AND ENVIRONMENTAL RESEARCH CORPORATION
18 MASON
IRVINE CALIFORNIA 92714

C POROUS PARTICLE MODEL WITH SINGLE STEP HETEROGENEOUS REACTION
C A(GAS) + B(SOLID) = C(GAS) + D(SOLID)
C ***** BY C. J. KAU (1/12/83) *****
C EDITED BY W. CLARK (3/25/83)

C NOTE THAT PROGRAM LINES ENDING IN ! *****
C MAY HAVE TO BE MODIFIED TO FIT CERTAIN CONDITIONS

C DIMENSION TIMETB(20), TTTB(20), TPRT(20)
C COMMON/SOLIDP/ RD, XLD, SD, POSTYD, OMEGAD, RHOSB, WTMOLB, VOLMB, VOLMD
C 1. ADP, BDP, AKSEGM, BKSEGM, AKS, BKS, SHERMD, BX, AX, WTMOLA, KASE
C COMMON/CPARAM/ BETAX, XKS, XKSB, STRUCT, BZOSTR, TIMED

C PRESET RATE CONSTANTS

C BHATIA RATE CONSTANTS FROM CURVE FIT TO BORGHARDT DATA

C DATA ADP, BDP, AKS, BKS, AKSEGM, BKSEGM/0.052B, 28000., 1890., 13500.,
C 1.896E-13, -110638.1/

C PRESET TEMPERATURE HISTORY ! *****

C DATA NTTTB, TIMETB, TTTB/7, 0.0, 0.3, 0.55, 0.8, 1.05, 1.3, 1.45,
C 113*1.45, 1533., 1472., 1405., 1333., 1122., 900., 767., 13*767./

C PRESET PRINT STATION ! *****

C DATA NPRT, TPRT/7, 0.0, 0.3, 0.55, 0.8, 1.05, 1.3, 1.45, 13*1.45/

C OPEN DATA FILE

C OPEN(UNIT=1, NAME='PORE.DAT', TYPE='OLD')

C PRESET

C AX=1.0

C BX=1.0

C VOLMB= 16.7

C VOLMD= 45.99

C WTMOLA= 64.06

C WTMOLB= 56.1

C P= 1.0 ! *****

C 1 CONTINUE

C TIME= 0.0

0001

0002

0003

0004

0005

0006

0007

0008

0009

0010

0011

0012

0013

0014

0015

0016

```

FORTRAN IV      V02.5      MON 07-NOV-83 15:25:43      PAGE 002
POREEPA, POREEPA=POREEPA

0017      TIMEX= 10.      ! *****
0018      IF (NTTB.GT.1) TIMEX= TIMETB(NTTB)
0020      DTIME= TIMEX*0.001
C
C      INPUT CASE CONDITION
C
0021      READ(1,*) KASE, NTTB, T, XAB, RO, XLO, SO, POSTYO, OMEGAD, RHOSB, XCAOSI
C
0022      IF (KASE.LE.0) GO TO 9
0024      WRITE(6,99)
0025      CALL CONVSN(T, P, XAB, TIME, DTIME, TIMEX, OACONV, RATEPA, SUMRPA
0026      , XCAOSI, NTTB, TIMETB, TTTB, NPRT, TPRT)
0027      GO TO 1
C
0028      99 FORMAT(1H1)
0029      109 FORMAT(2X, I5, 1P10E10.3)
C
0030      9 CONTINUE
0031      CLOSE(UNIT=1, DISP='SAVE')
0032      CALL EXIT
0033      END

```

FORTAN IV STORAGE MAP FOR PROGRAM UNIT MAIN.

LOCAL VARIABLES, PSECT \$DATA, SIZE = 000434 (142. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
DTIME	R*4	000400	NPRT	I*2	000362	NTTIB	I*2	000360
DACONV	R*4	000420	P	R*4	000364	RATEPA	R*4	000424
SUMRPA	R*4	000430	T	R*4	000404	TIME	R*4	000370
TIMEMX	R*4	000374	XAB	R*4	000410	XCAOSI	R*4	000414

COMMON BLOCK /SOLIDP/, SIZE = 000116 (39. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
RO	R*4	000000	XLO	R*4	000004	SD	R*4	000010
POSTYO	R*4	000014	OMEGAD	R*4	000020	RHOSB	R*4	000024
WTMLB	R*4	000030	VOLMB	R*4	000034	VOLMD	R*4	000040
ADP	R*4	000044	BDP	R*4	000050	AKSEOM	R*4	000054
BKSEGM	R*4	000060	AKS	R*4	000064	BKS	R*4	000070
SHERWD	R*4	000074	BX	R*4	000100	AX	R*4	000104
WTMLA	R*4	000110	KASE	I*2	000114			

COMMON BLOCK /CPARAM/, SIZE = 000030 (12. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
BETAX	R*4	000000	XKS	R*4	000004	XKSB	R*4	000010
STRUCT	R*4	000014	BZOSTR	R*4	000020	TIMED	R*4	000024

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	-----SIZE-----	DIMENSIONS
TIMETB	R*4	\$DATA	000000	000120 (40.)	(20)
TPRT	R*4	\$DATA	000240	000120 (40.)	(20)
TTTB	R*4	\$DATA	000120	000120 (40.)	(20)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE
CONVSN	R*4	EXIT	R*4				

0001 SUBROUTINE CONVSN(T,P,XAB,TIME,DTIME,TIMEX,DACONV,RATEPA,SUMRPA
1 ,XCAOSI,NTTIB,TIMETB,TTTB,NPRT,TPRT)

```

C
C POROUS PARTICLE MODEL WITH SINGLE STEP HETEROGENEOUS REACTION
C A(GAS) + B(SOLID) = C(GAS) + D(SOLID)
C BY C. J. KAU (1/12/83)
C EDITED BY W. CLARK (3/25/83)
C ***** ALL UNITS IN C-G-S SYSTEM
C ***** INPUT PARAMETERS
C A=S02
C B=CAO
C C=NOTHING
C D=CAS03 WHICH GOES INSTANTANEOUSLY TO CAS04
C RO = RADIUS OF THE PARTICLE (CM)
C XLD = INITIAL TOTAL LENGTH OF PORE SYSTEM PER UNIT VOLUME (CM/CM3)
C SO = INITIAL PORE SURFACE AREA PER UNIT VOLUME (CM2/CM3)
C POSTVO= INITIAL POROSITY (CM3/CM3)
C OMEGAO= MASS FRACTION OF B IN INITIAL SOLID PARTICLE
C RHOSB = INITIAL BULK DENSITY OF SOLID PARTICLE (G/CC)
C WTMOLA= MOLECULAR WEIGHT OF A (G/MOLE)
C WTMOLB= MOLECULAR WEIGHT OF B (G/MOLE)
C VOLMB = MOLAR VOLUME OF B (CC/MOLE)
C VOLMD = MOLAR VOLUME OF D (CC/MOLE)
C ADP = PRE-CONSTANT FOR EFFECTIVE DIFFUSIVITY OF A IN PRODUCT
C BDP = LAYER (CM2/SEC)
C AKS = ACTIVATION ENERGY FOR EFFECTIVE DIFF. OF A IN PRODUCT
C BKS = LAYER (CAL/G-MOLE)
C SHERWD= SHERWOOD NO. FOR SURFACE REACTION RATE (CM4/(G-MOLE SEC))
C STCOICHO= ACTIVATION ENERGY FOR SURFACE REACTION RATE (CAL/G-MOLE)
C STCOICHO= SHERWOOD NO. FOR BOUNDARY MASS TRANSFER COEFFICIENT OF A
C STCOICHO= STOICHIOMETRIC COEFFICIENTS: aA +bB = cC +dD
C a, b, c, AND d ARE STOICHIOMETRIC COEFFICIENTS
C AX = STOICHIOMETRIC COEFFICIENTS OF A
C BX = STOICHIOMETRIC COEFFICIENTS OF B
C T = TEMPERATURE (K)
C P = PRESSURE(ATM)
C XAB = FREE-STREAM MOLE FRACTION OF A
C XCAOSI= CA/S MOLE RATIO
C TIME = REAL TIME (SEC)
C DTIME = INTEGRATION TIME STEP (SEC)
C TIMEX= MAXIMUM TIME FOR INTEGRATION (SEC)
C NTTIB = NO. OF ENTRIES FOR TEMPERATURE HISTORY TABLE(MAX. 20)
C TIMETB= TIME(SEC) TABLE ENTRIES
C TTTB = TEMPERATURE(K) TABLE ENTRIES
C NPRT = NO. OF PRINT STATIONS(MAX. 20)
C TPRT = PRINT STATION IN TIME(SEC)
C MXSP = NUMBER OF GRIT POINTS USED IN NUMERICAL INTEGRATION
C *****OUTPUT
C DAONV= OVERALL CONVERSION OF SOLID B
C RATEPA= REACTION RATE OF A PER PARTICLE (MOLE/P-SEC)
C SUMRPA= TOTAL CURRENT REACTION OF A PER PARTICLE (MOLE/P)
C XNPLIM= NO. OF PARTICLE PER MOLE OF GAS MIXTURE
C
C DIMENSION TIMETB(NTTIB), TTTB(NTTIB), TPRT(NPRT)

```

```

0003 DIMENSION VS(11),DYS(11),CISPA(11),X(11),DESTAR(11),DXDTAU(11)
0004 1 .POSTYR(11),AA(11),VYS(11),SAVEC(11),SAVEX(11)
0005 COMMON/CPARAM/ BETAX,XKS,XKSB,STRUCT,BZOSTR,TIMED
0006 COMMON/XXXXX1/ A(11),B(11),C(11),G(11),BETA(2),GAMA(2),EATA(2)
0007 1 .ADP,BDP,AKSEGM,BKSEGM,AKS,BKS,SHERWD,BX,AX,WTMOLA,KASE
DATA SHERWD/2./MXSP,IOFLAG/11,1/ ! *****

```

C

SET ZEROS

IF (TIME.GT.0.0) GO TO 3

IPRT= 1

TIME= 0.0

DTMAX= 0.05*TIMEX

DTDTIN= 0.0

TAU= 0.0

NXSP= MXSP -1

DYSO= 1.0/NXSP

DYS(1)= 0.0

VS(1)= 0.0

VYS(1)= 0.0

DO 1 M=2,MXSP

DYS(M)= DYSO

VYS(M)= VYS(M-1)+ DYS(M)

VYS(M)= VYS(M)*VYS(M)

1 CONTINUE

OACONV= 0.0

RATEPA= 0.0

CAPTR= 0.0

XKSEGM= 0.0

SUMRPA= 0.0

DO 2 M=1,MXSP

X(M)= 0.0

CISPA(M)= 0.0

2 CONTINUE

VP= 4.18879*RO**3

XNPLIM= 56.*XCAOSI*XAB/(RHOSB*OMEGAD*VP)

RHO= RHOSB*OMEGAD/(1.0-POSTYO)

ZX= 1.0+ RHO*VOLMB*(VOLMD/VOLMB- 1.0)/WTMOLB

STRUCT= 12.56637*XLO*(1.0- POSTYO)/(SO*SO)

POPLUG= (ZX- 1.0)*(1.0- POSTYO)

WRITE(6,108) KASE,RO,SO,XLO,P,OMEGAD,XNPLIM,XCAOSI,RHOSB

1 .STRUCT,SHERWD,ZX

WRITE(6,107)

WRITE(6,100) TIME,T,POSTYO,CAPTR,OACONV,XAS,RATEPA,SUMRPA,

1 XKSEGM,DTIME

C
C
C
C

PRESET PHYSICAL AND CHEMICAL CONSTANTS

3 CONTINUE

IF (XAB.LE.0.0) RETURN

SAVXAB= XAB

SVSRPA= SUMRPA

SVDACV= OACONV

0043
0044
0046
0047
0048

```

0049 SVTIME= TIME
0050 DO 5 M=1, MXSP
0051 SAVEC(M)= CISPA(M)
0052 SAVEX(M)= X(M)
0053 5 CONTINUE
0054 TIME= SVTIME+ DTIME
0055 TIME5= SVTIME+ 0.5*DTIME
0056 IF (NTTB.LE.1) GO TO 10
0057 CALL TKEY(TIME5, TIMEB, ITKEY, SDT, HDT, NTTTB, DTIME)
0058 ITKEY1= ITKEY+ 1
0059 T= ITTB(ITKEY)*HDT+ ITTB(ITKEY1)*SDT
0060 DDTIM= (ITTB(ITKEY1)-ITTB(ITKEY))/(TIMEB(ITKEY1)-TIMEB(ITKEY))
0061 10 CONTINUE
0062 RTI= 1.0/(1.987*T)
0063 DP= ADP*EXP(-BDP*RTI)
0064 XKS= AKS*EXP(-BKS*RTI)
0065 XKSEQM= AKSEQM*EXP(-BKSEQM*RTI)
0066 XKS= XKS/XKSEQM
0067 CISPAB= XAB*P/(82.06*T)
0068 BETAX= 2.0*XKS*AX*RH0*(1.0- POSTYO)/(WTMOLB*B*DP*SD)
0069 DKO= 9.7E3*(2.0*POSTYO/SD)*SQRT(T/WTMOLA)
0070 DA= EXP(1.66*ALOG(T)- 11.30)
0071 DO= 1.0/(1.0/DA+ 1.0/DKO)
0072 DEO= POSTYO**2*DO
0073 THIELE= RO*SQRT(XKS*AX*RH0*SD)/(WTMOLB*B*DEO)
0074 THIELE2= THIELE*THIELE
0075 BZOSTR= BETAX*ZX/STRUCT
0076 TIMEO= (1.0- POSTYO)/(XKS*CISPAB*SD)
0077 C
C
C
0078 SAVTAU= TAU
0079 DTAU= DTIME/TIMEO
0080 TAU= SAVTAU+ DTAU
0081 DTAU5= 0.5*DTAU
0082 TAU5= SAVTAU+ DTAU5
0083 DO 11 M=1, MXSP
0084 T1= FUN(CISPA(M), SAVTAU, SAVEX(M), T)
0085 XT1= SAVEX(M)+ T1*DTAU5
0086 T2= FUN(CISPA(M), TAU5, XT1, T)
0087 XT2= SAVEX(M)+ T2*DTAU5
0088 T3= FUN(CISPA(M), TAU5, XT2, T)
0089 XT3= SAVEX(M)+ T3*DTAU
0090 T4= FUN(CISPA(M), TAU, XT3, T)
0091 DXDTAU(M)= (T1+ 2.0*T2+ 2.0*T3+ T4)/6.0
0092 X(M)= SAVEX(M)+ DXDTAU(M)*DTAU
0093 IF (X(M).GT.1.0) X(M)= 1.0
0094 POSTYR(M)= 1.0- PDLUG*X(M)/POSTYO
0095 DESTAR(M)= POSTYR(M)
0096 AA(M)= DESTAR(M)*YYS(M)
0097 11 CONTINUE
0098 C
C
C
OVERALL CONVERSION
C
C

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POREEPA:POREEPA=POREEPA

0099      SUMX= 0.0
0100      SUMDX= 0.0
0101      DO 6 M=2, MXSP
0102      MM1= M- 1
0103      DVOLM2= (YVS(M)+YVS(MM1))*DVS(M)
0104      SUMX= SUMX+ (X(M)+X(MM1))*DVOLM2
0105      SUMDX= SUMDX+ (DXDTAU(M)+DXDTAU(MM1))*DVOLM2
0106      6 CONTINUE
0107      DACONV= 0.75*SUMX
0108      RATEPA= -0.75*VP*AX*RHQ*(1.0-POSTVO)/(BX*WTMOLB*TIMEO)*SUMDX
0109      SUMRPA= SVSRPA+ RATEPA*DTIME
0110      POSTY= POSTYO- POPLUG*DAONV
0111      CAPTUR= XCADSI*DAONV

C
C      SETTING UP TRI-DIAGONAL MATRIX
C
0112      DO 12 M=2, NXSP
0113      MM1= M- 1
0114      MP1= M+ 1
0115      DVB= 0.5*(DYS(MP1)+ DYS(M))
0116      AM= 0.5*(AA(MP1)+ AA(M))/(DVB*DYS(MP1))
0117      BM= 0.5*(AA(MM1)+ AA(M))/(DVB*DYS(M))
0118      XI= 1.0- X(M)
0119      IF (XI.GT.0.0) SGRTX= SQRT(1.0- STRUCT*ALOG(XI))
0120      DXDTDA= XI*SGRTX/(1.0+ BZOSTR*(SGRTX- 1.0))
0121      A(M)= -BM
0122      B(M)= BM- AM- THIEL2*YVS(M)*DXDTDA
0123      C(M)= AM
0124      G(M)= 0.0
0125      12 CONTINUE
0126

C
C      SOLVING TRI-DIAGONAL MATRIX
C
0127      BETA(1)= -DYS(2)*DYS(2)*THIEL2*DXDTAU(1)/(6.*DESTAR(1))
0128      GAMA(1)= 1.0
0129      EATA(1)= 0.0
0130      SSS= DYS(MXSP)*SHERND/DESTAR(MXSP)
0131      SSS11= 1.0/(SSS+ 1.0)
0132      BETA(2)= SSS*SSS11
0133      GAMA(2)= SSS11
0134      EATA(2)= 0.0
0135      CALL TRIDMX(MXSP,CISPA)

C
C      INTEGRATE FREE-STREAM SPECIES EQUATION
C
0136      XAB= SAVXAB+ XNPLIM*RATEPA*DTIME
0137      IF (XAB.LT.0.0) XAB= 0.0

C
C      PRINT OUTPUT
C
0139      IF (IOFLAG.EQ.0) GO TO 8
0140      DO 20 I=1,IPRT,NPRT
0141      IF (ABS(TIME-IPRT(I)).LT.0.1*DTIME) GO TO 21
0142      20 CONTINUE
0143

```

```

0145 GO TO B
0146 21 CONTINUE
0147 IPRT= I+ 1
0148 WRITE(6,100) TIME, T, POSTY, CAPTUR, OACONV, XAB, RATEPA, SUMRPA,
      1 XKSEGM, DTIME
0149 IF (IDFLAG.EQ.1) GO TO B
0150 WRITE(6,101) (YS(M), M=1, MXSP)
0151 WRITE(6,102) (CISPA(M), M=1, MXSP)
0152 WRITE(6,103) (X(M), M=1, MXSP)
0153 WRITE(6,104) (DXDTAU(M), M=1, MXSP)
0154 WRITE(6,105) (POSTYR(M), M=1, MXSP)
0155 WRITE(6,106) (DESTAR(M), M=1, MXSP)
0156
      C
      C STEP SIZE CONTROL
      C
0157 B CONTINUE
0158 CHK= ABS(OACONV- SVDACV)
      C
      C INCREASE STEP SIZE
      C
0159 IF (CHK.LT.0.001) DTIME= DTIME+ DTIME ! *****
0160 IF (CHK.LT.0.05) GO TO 22
0161 TIME= SVTIME
0162 DTIME= 0.5*DTIME
0163 TAU= SAVTAU
0164 XAB= SAVXAB
0165 SUMRPA= SVSRPA
0166 DO 23 M=1, MXSP
0167 CISPA(M)= SAVEC(M)
0168 X(M)= SAVEX(M)
0169 23 CONTINUE
0170 GO TO 3
0171 22 CONTINUE
0172 IF (DTIME.GT.DTIMAX) DTIME= DTIMAX
0173 DTCHK= IPRT(IPRT)- TIME
0174 IF (DTCHK.LT.DTIME AND. DTCHK.GT.0.0) DTIME= DTCHK
0175 IF ((DTDTIM*DTIME).GT.20.) DTIME= 20./DTDTIM
0176 IF (TIME.LT. TIMENX) GO TO 3
      C
0177 100 FORMAT(3X, F6.2, 2X, F7.2, 3(3X, F5.3), 1P5(2X, E10.3))
0178 101 FORMAT(2X, 9HYS(M) , 1P12E10.3)
0179 102 FORMAT(2X, 9HCISPA(M) , 1P12E10.3)
0180 103 FORMAT(2X, 9HX(M) , 1P12E10.3)
0181 104 FORMAT(2X, 9HDXDTAU(M), 1P12E10.3)
0182 105 FORMAT(2X, 9HPOSTYR(M), 1P12E10.3)
0183 106 FORMAT(2X, 9HDESTAR(M), 1P12E10.3)
0184 107 FORMAT(3X, TIME(S), 2X, 'T(K)', 2X, 'POROSITY', 2X, 'CAPTURE', 2X, 'OACO
      1NV', 6X, 'XAB', 6X, 'RATEPA', 6X, 'SUMRPA', 6X, 'XKSEGM', 6X, 'DTIME'//
0185 1 /10X, 'PORE SURFACE(CM2/CM3)', E10.3/10X, 'PARTICLE RADIUS(CM)', 1P12E10.3
0186 2 E10.3/10X, 'PRESSURE(ATM)', E10.3/10X, 'PORE LENGTH(CM/CM3)',
0187 3 REACTANT=, E10.3/10X, 'NO. OF PARTICLE/MOLE OF GAS MIXTURE=,
0188 4 E10.3/10X, 'CA/S', E10.3/10X, 'BULK DENSITY OF PARTICLE=, E10.3
0189 5 /10X, 'STRUCTURE PARAMETER=, E10.3/10X, 'SHERWOOD NO.=, E10.3
0190
0191

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POREEPA, POREEPA=POREEPA

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6 /10X, 'VOLUME RATIO OF SOLID PHASE AFTER TO BEFORE REACTION-'
7 E10.3)

C

0192
0193

RETURN
END

FORTAN IV STORAGE MAP FOR PROGRAM UNIT CONVEN

LOCAL VARIABLES, PSECT \$DATA, SIZE = 001564 (442. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
AM	R*4	001422	BM	R*4	001426	CAPTUR	R*4	001156
CHK	R*4	001460	CISPAB	R*4	001262	DA	R*4	001272
DEO	R*4	001302	DKO	R*4	001266	DO	R*4	001276
DP	R*4	001256	DTAU	R*4	001322	DTAUS	R*4	001326
DTCHK	R*4	001464	DTDTIM	R*4	001136	DTIMAX	R*4	001132
DTIME	R*4	000010	DVLM2	R*4	001404	DXDTDA	R*4	001442
DVB	R*4	001416	DYSO	R*4	001150	HDT	R*4	001244
I	I*2	001456	IOFLAG	I*2	001004	IPRT	R*4	001130
ITKEY	I*2	001236	ITKEY1	I*2	001250	M	I*2	001154
MM1	I*2	001402	MP1	I*2	001414	MXSP	I*2	001002
NPRT	I*2	000032	NTTIB	I*2	000024	NXSP	I*2	001146
OACONV	R*4	000014	P	R*4	000002	POPLUG	R*4	001206
POSTY	R*4	001410	RATEPA	R*4	000016	RHO	R*4	001176
RTI	R*4	001252	SAVTAU	R*4	001316	SAVXAB	R*4	001212
SDT	R*4	001240	SORTX	R*4	001436	SSS	R*4	001446
SSS11	R*4	001452	SUMDX	R*4	001376	SUMRPA	R*4	000020
SUMX	R*4	001372	SVDACV	R*4	001222	SVSRPA	R*4	001216
SVTIME	R*4	001226	T	R*4	000000	TAU	R*4	001142
TAU5	R*4	001332	THIELE	R*4	001306	THIEL2	R*4	001312
TIME	R*4	000006	TIMEX	R*4	000012	TIME5	R*4	001232
T1	R*4	001336	T2	R*4	001346	T3	R*4	001356
T4	R*4	001366	VP	R*4	001166	XAB	R*4	000004
XCAOSI	R*4	000022	XKSEGM	R*4	001162	XNPLIM	R*4	001172
XT1	R*4	001342	XT2	R*4	001352	XT3	R*4	001362
X1	R*4	001432	ZX	R*4	001202			

COMMON BLOCK /CPARAM/, SIZE = 000030 (12. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
BETAX	R*4	000000	XKS	R*4	000004	XKSB	R*4	000010
STRUCT	R*4	000014	BZOSTR	R*4	000020	TIMED	R*4	000024

COMMON BLOCK /XXXXX1/, SIZE = 000310 (100. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
A	R*4	000000	B	R*4	000054	C	R*4	000130
G	R*4	000204	BETA	R*4	000260	GAMA	R*4	000270
EATA	R*4	000300						

COMMON BLOCK /SOLIDP/, SIZE = 000116 (39. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
RO	R*4	000000	XLO	R*4	000004	SO	R*4	000010
POSTYO	R*4	000014	OMEGAD	R*4	000020	RHOSB	R*4	000024
WTMOLB	R*4	000030	VOLNB	R*4	000034	VOLMD	R*4	000040
ADP	R*4	000044	BDP	R*4	000050	AKSEGM	R*4	000054
BKSEGM	R*4	000060	AKS	R*4	000064	BKS	R*4	000070
SHERND	R*4	000074	EX	R*4	000100	AX	R*4	000104
WTMOLA	R*4	000110	KASE	I*2	000114			

FORTAN IV STORAGE MAP FOR PROGRAM UNIT CONVSN

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	-----SIZE-----	DIMENSIONS
A	R*4	XXXXX1	000000	000054 (	22.) (11)
AA	R*4	\$DATA	000522	000054 (	22.) (11)
B	R*4	XXXXX1	000054	000054 (	22.) (11)
BETA	R*4	XXXXX1	000260	000010 (	4.) (2)
C	R*4	XXXXX1	000130	000054 (	22.) (11)
CISPA	R*4	\$DATA	000166	000054 (	22.) (11)
DESTAR	R*4	\$DATA	000316	000054 (	22.) (11)
DXDTAU	R*4	\$DATA	000372	000054 (	22.) (11)
DYS	R*4	\$DATA	000112	000054 (	22.) (11)
EATA	R*4	XXXXX1	000300	000010 (	4.) (2)
GAMA	R*4	XXXXX1	000270	000010 (	4.) (2)
POSTYR	R*4	\$DATA	000446	000054 (	22.) (11)
G	R*4	XXXXX1	000204	000054 (	22.) (11)
SAVEC	R*4	\$DATA	000652	000054 (	22.) (11)
SAVEX	R*4	\$DATA	000726	000054 (	22.) (11)
TIMETB	R*4	\$DATA	000026	**** (	**) (NTTB)
TPRT	R*4	@ \$DATA	000034	**** (	**) (NPRT)
TTTB	R*4	@ \$DATA	000030	**** (	**) (NTTB)
X	R*4	\$DATA	000242	000054 (	22.) (11)
YS	R*4	\$DATA	000036	000054 (	22.) (11)
YYS	R*4	\$DATA	000576	000054 (	22.) (11)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME	TYPE	NAME	TYPE	NAME	TYPE
ABS	R*4	ALOG	R*4	NAME	R*4
TKEY	R*4	TRIDHX	R*4	SGRT	R*4

```

0001      FUNCTION FUN(CISPA, TAU, X, T)
      C
      C      CALCULATION OF TIME RATE OF CONVERSION
      C
      COMMON/CPARAM/ BETAX, XKS, XKS9, STRUCT, BZOSTR, TIMED
      X1= 1.0- X
      IF (X1.GT. 0.0) SGRTX= SORT(1.0- STRUCT*ALOG(X1))
      C
      C      TURN OFF FORWARD REACTION AT 2300 F (1533 K)
      C
      FRATE=0.
      IF (T .LT. 1533.33)
      1FRATE= CISPA*X1*SGRTX/(1.0+ BZOSTR*(SGRTX- 1.0))
      C
      C      ASSUME BACKWARD REACTION NEGLIGIBLE BELOW CUTOFF TEMPERATURE
      C
      BRATE=0.
      FUN= FRATE- BRATE
      RETURN
      END
0009
0010
0011
0012
    
```

FORTAN IV STORAGE MAP FOR PROGRAM UNIT FUN

LOCAL VARIABLES, .PSECT *DATA, SIZE = 000040 (16. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
BRATE	R*4	000030	CISPA	R*4 @	000000	FRATE	R*4	000024
FUN	R*4	000010	Eqv	SGRTX	R*4	T	R*4 @	000006
TAU	R*4 @	000002	X	R*4 @	000004	X1	R*4	000014

COMMON BLOCK /CPARAM/, SIZE = 000030 (12. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
BETAX	R*4	000000	XKS	R*4	000004	XKSB	R*4	000010
STRUCT	R*4	000014	BZOSTR	R*4	000020	TIMED	R*4	000024

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE
ALOG	R*4	SGRT	R*4				


```

0001      C      SUBROUTINE TRIDMX(N, X)
      C
0002      C      SOLVE TRI-DIAGONAL MATRIX(M) WITH SPECIFIED B. C.
0003      C      DIMENSION X(11), F(11), G(11)
      C      COMMON/XXXXX1/ A(11), B(11), C(11), G(11), BETA(2), GAMA(2), EATA(2)
0004      C      NM1= N- 1
0005      C      NM2= N- 2
      C
0006      C      LOWER B. C.
      C
0007      C      B(2)= B(2)+ A(2)*GAMA(1)
0008      C      C(2)= C(2)+ A(2)*EATA(1)
      C      G(2)= G(2)- A(2)*BETA(1)
      C
0009      C      UPPER B. C.
      C
0010      C      B(NM1)= B(NM1)+ C(NM1)*GAMA(2)
0011      C      A(NM1)= A(NM1)+ C(NM1)*EATA(2)
      C      G(NM1)= G(NM1)- C(NM1)*BETA(2)
      C
0012      C      FORWARD PASS
      C
0013      C      F(2)= C(2)/B(2)
0014      C      G(2)= G(2)/B(2)
0015      C      DO 2 I=3, NM1
0016      C      IM1= I- 1
0017      C      XX= B(I)- A(I)*F(IM1)
0018      C      F(I)= C(I)/XXX
0019      C      G(I)= (G(I)- A(I)*G(IM1))/XXX
      C      2 CONTINUE
      C
0020      C      BACKWARD PASS
      C
0021      C      X(NM1)= G(NM1)
0022      C      DO 3 I=2, NM2
0023      C      II= N- I
0024      C      X(II)= G(II)- F(II)*X(II+1)
      C      3 CONTINUE
      C
0025      C      BOUNDARY CONDITIONS
      C
0026      C      X(1)= BETA(1)+ GAMA(1)*X(2)+ EATA(1)*X(3)
      C      X(N)= BETA(2)+ GAMA(2)*X(NM1)+ EATA(2)*X(NM2)
0027      C      RETURN
0028      C      END

```

FORTRAN IV STORAGE MAP FOR PROGRAM UNIT TRIDMX

LOCAL VARIABLES, .PSECT \$DATA, SIZE = 000172 (61. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
I	I*2	000154	II	I*2	000164	IM1	I*2	000156
N	I*2 @	000000	NM1	I*2	000150	NM2	I*2	000152
XXX	R*4	000160						

COMMON BLOCK /XXXXX1/, SIZE = 000310 (100. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
A	R*4	000000	B	R*4	000054	C	R*4	000130
G	R*4	000204	BETA	R*4	000260	GAMA	R*4	000270
EATA	R*4	000300						

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	-----SIZE-----	DIMENSIONS
A	R*4	XXXXX1	000000	000054 (	22.) (11)
B	R*4	XXXXX1	000054	000054 (	22.) (11)
BETA	R*4	XXXXX1	000260	000010 (	4.) (2)
C	R*4	XXXXX1	000130	000054 (	22.) (11)
EATA	R*4	XXXXX1	000300	000010 (	4.) (2)
F	R*4	\$DATA	000004	000054 (	22.) (11)
G	R*4	\$DATA	000060	000054 (	22.) (11)
GAMA	R*4	XXXXX1	000270	000010 (	4.) (2)
G	R*4	XXXXX1	000204	000054 (	22.) (11)
X	R*4	@ \$DATA	000002	000054 (	22.) (11)

```

0001 C SUBROUTINE TKEY(T, TTB, ITKEY, SDT, HDT, NT, DTIME)
0002 C DIMENSION TTB(NT)
0003 NT1=NT-1
0004 DO 10 IT=1, NT1
0005 DT= TTB(IT+1)-TTB(IT)
0006 SDT=(T-TTB(IT))/DT
0007 HDT=(TTB( IT+1)-T) /DT
0008 SDT=(T-TTB(IT))/DT
0009 HDT=(TTB( IT+1)-T) /DT
0010 IF ((SDT*HDT).GE.0.0) GO TO 11
0011 10 CONTINUE
0012 WRITE(6,100) T, IT
0013 WRITE(6,8101) DTIME
0014 B101 FORMAT(' DTIME = ',E15.5)
0015 STOP
0016 C
0017 11 ITKEY=IT
0018 RETURN
0019 C
0020 100 FORMAT(1H , , TEMPERATURE OUT OF RANGE ', E14.5, 15)
END

```

FORTAN IV STORAGE MAP FOR PROGRAM UNIT TKEY

LOCAL VARIABLES, .PSECT \$DATA, SIZE = 000042 (17. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
DT	R*4	000026	DTIME	R*4	@ 000014	HDT	R*4	@ 000010
IT	I*2	000024	ITKEY	I*2	@ 000004	NT	I*2	@ 000012
NT1	I*2	000022	SDT	R*4	@ 000006	T	R*4	@ 000000

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	-----SIZE-----	DIMENSIONS
TTB	R*4	@ \$DATA	000002	*** (**)	(NT)

1. 7, 1533, 2500. E-6, 2. 5E-4, 49 29E8, 20 44E4, 725, 97, 8257, 2 0
2. 7, 1533, 2500. E-6, 2. 5E-4, 23 91E8, 14 37E4, 725, 97, 8257, 2 0
3. 7, 1533, 2500. E-6, 2. 5E-4, 13 96E8, 10 98E4, 725, 97, 8257, 2 0
4. 7, 1533, 2500. E-6, 2. 5E-4, 8 52E8, 8 58E4, 725, 97, 8257, 2 0
5. 7, 1533, 2500. E-6, 2. 5E-4, 6 12E8, 7 27E4, 725, 97, 8257, 2 0
0. 7, 1533, 2500. E-6, 2. 5E-4, 6 12E8, 7 27E4, 725, 97, 8257, 2 0

1 1. 533E+03 2. 500E-03 2. 500E-04 4. 929E+09 2. 064E+05 7. 250E-01 9. 700E-01 8. 257E-01 2. 000E+00

CASE NO = 1

PARTICLE RADIUS(CM)= 2. 500E-04

PORE SURFACE(CM2/CM3)= 2. 064E+05

PORE LENGTH(CM/CM3)= 4. 929E+09

PRESSURE(ATM)= 1. 000E+00

MASS FRAX OF SOLID REACTANT= 9. 700E-01

NO. OF PARTICLE/MOLE OF GAS MIXTURE= 5. 341E+09

CA/S= 2. 000E+00

BULK DENSITY OF PARTICLE= 8. 257E-01

STRUCTURE PARAMETER= 3. 998E-01

SHERWOOD NO. = 2. 000E+00

VOLUME RATIO OF SOLID PHASE AFTER TO BEFORE REACTION= 2. 521E+00

TIME(S)	T(K)	POROSITY	CAPTURE	DACONV	XAB	RATEPA	SUMRPA	XKSEQM	DTIME
0. 00	1533. 00	0. 725	0. 000	0. 000	2. 500E-03	0. 000E-01	0. 000E-01	0. 000E-01	1. 450E-03
0. 30	1472. 56	0. 691	0. 161	0. 080	2. 097E-03	-2. 002E-13	-7. 500E-14	3. 007E+03	5. 800E-03
0. 55	1405. 84	0. 673	0. 249	0. 124	1. 877E-03	-1. 357E-13	-1. 162E-13	3. 013E+04	6. 250E-03
0. 80	1334. 80	0. 661	0. 308	0. 154	1. 730E-03	-9. 152E-14	-1. 441E-13	2. 479E+09	1. 250E-02
1. 05	1137. 83	0. 654	0. 338	0. 169	1. 656E-03	-3. 093E-14	-1. 580E-13	3. 393E+08	3. 751E-02
1. 30	929. 96	0. 653	0. 345	0. 172	1. 640E-03	-4. 191E-15	-1. 610E-13	1. 909E+13	6. 749E-02
1. 44	803. 58	0. 653	0. 345	0. 172	1. 639E-03	-5. 436E-16	-1. 612E-13	2. 348E+17	7. 250E-02
1. 45	769. 22	0. 653	0. 345	0. 172	1. 639E-03	-2. 674E-16	-1. 612E-13	5. 187E+18	5. 000E-03

2 1.53E+03 2.50E-03 2.50E-04 2.391E+09 1.437E+05 7.250E-01 9.700E-01 8.257E-01 2.000E+00

CASE NO. = 2
 PARTICLE RADIUS(CM)= 2.500E-04
 PORE SURFACE(CM2/CM3)= 1.437E+05
 PORE LENGTH(CM/CM3)= 2.391E+09
 PRESSURE(ATM)= 1.000E+00
 MASS FRAX OF SOLID REACTANT= 9.700E-01
 NO. OF PARTICLE/MOLE OF GAS MIXTURE= 5.341E+09
 CA/S= 2.000E+00
 BULK DENSITY OF PARTICLE= 8.257E-01
 STRUCTURE PARAMETER= 4.001E-01
 SHERWOOD NO.= 2.000E+00
 VOLUME RATIO OF SOLID PHASE AFTER TO BEFORE REACTION= 2.521E+00

TIME(S)	T(K)	POROSITY	CAPTURE	OACONV	XAB	RATEPA	SUMRPA	XKSEGM	DTIME
0.00	1533.00	0.725	0.000	0.000	2.500E-03	0.000E-01	0.000E-01	0.000E-01	1.450E-03
0.30	1473.15	0.701	0.116	0.058	2.211E-03	-1.501E-13	-3.412E-14	4.931E+03	1.160E-02
0.55	1405.84	0.687	0.183	0.092	2.043E-03	-1.053E-13	-8.552E-14	3.013E+04	6.250E-03
0.80	1334.80	0.677	0.230	0.115	1.926E-03	-7.281E-14	-1.074E-13	2.480E+03	1.249E-02
1.05	1132.64	0.672	0.254	0.127	1.867E-03	-2.378E-14	-1.185E-13	4.245E+08	2.322E-02
1.30	935.83	0.671	0.259	0.129	1.854E-03	-3.557E-15	-1.209E-13	1.310E+13	7.250E-02
1.45	771.04	0.671	0.259	0.130	1.853E-03	-2.165E-16	-1.210E-13	4.370E+18	9.120E-03

3 1.533E+03 2.500E-03 2.500E-04 1.396E+09 1.098E+05 7.250E-01 9.700E-01 8.257E-01 2.000E+00

CASE NO. = 3

PARTICLE RADIUS(CM) = 2.500E-04
 PORE SURFACE(CM2/CM3) = 1.098E+05
 PORE LENGTH(CM/CM3) = 1.396E+09
 PRESSURE(ATM) = 1.000E+00

MASS FRAX OF SOLID REACTANT = 9.700E-01
 NO. OF PARTICLE/MOLE OF GAS MIXTURE = 5.341E+09
 CA/S = 2.000E+00

BULK DENSITY OF PARTICLE = 8.257E-01
 STRUCTURE PARAMETER = 4.002E-01

SHERWOOD NO. = 2.000E+00
 VOLUME RATIO OF SOLID PHASE AFTER TO BEFORE REACTION = 2.521E+00

TIME(S)	T(K)	POROSITY	CAPTURE	OACONV	XAB	RATEPA	SUMRPA	XKSEQM	DTIME
0.00	1533.00	0.725	0.000	0.000	2.500E-03	0.000E-01	0.000E-01	0.000E-01	1.450E-03
0.95	1406.68	0.695	0.144	0.072	2.140E-03	-8.586E-14	-6.736E-14	2.942E+04	1.160E-02
0.80	1335.66	0.687	0.183	0.091	2.044E-03	-6.024E-14	-8.532E-14	2.414E+05	1.845E-02
1.05	1126.28	0.683	0.202	0.101	1.995E-03	-1.873E-14	-9.446E-14	5.603E+08	1.015E-02
1.30	919.59	0.682	0.206	0.103	1.985E-03	-2.342E-15	-9.644E-14	3.752E+13	4.412E-02
1.44	803.58	0.682	0.207	0.103	1.984E-03	-3.448E-16	-9.654E-14	2.348E+17	7.230E-02
1.45	769.22	0.682	0.207	0.103	1.984E-03	-1.692E-16	-9.654E-14	5.187E+18	5.000E-03

4 1. 533E+03 2. 500E-03 2. 500E-04 8. 520E+08 8. 580E+04 7. 250E-01 9. 700E-01 8. 257E-01 2. 000E+00

CASE NO. = 4
 PARTICLE RADIUS(CM)= 2. 500E-04
 PORE SURFACE(CM2/CM3)= 8. 580E+04
 PORE LENGTH(CM/CM3)= 8. 520E+08
 PRESSURE(ATM)= 1. 000E+00
 MASS FRAX OF SOLID REACTANT= 9. 700E-01
 NO. OF PARTICLE/MOLE OF GAS MIXTURE= 5. 341E+09
 CA/S= 2. 000E+00
 BULK DENSITY OF PARTICLE= 8. 257E-01
 STRUCTURE PARAMETER= 4. 000E-01
 SHERWOOD NO. = 2. 000E+00
 VOLUME RATIO OF SOLID PHASE AFTER TO BEFORE REACTION= 2. 521E+00

TIME(S)	T(K)	POROSITY	CAPTURE	OACONV	XAB	RATEPA	SUMRPA	XKSEOM	DTIME
0. 00	1533. 00	0. 725	0. 000	0. 000	2. 500E-03	0. 000E-01	0. 000E-01	0. 000E-01	1. 450E-03
0. 30	1473. 15	0. 710	0. 072	0. 036	2. 321E-03	-9. 562E-14	-3. 343E-14	4. 931E+03	1. 160E-02
0. 55	1407. 39	0. 701	0. 115	0. 058	2. 212E-03	-7. 032E-14	-5. 384E-14	2. 884E+04	1. 785E-02
0. 80	1338. 17	0. 694	0. 147	0. 073	2. 134E-03	-5. 037E-14	-6. 854E-14	2. 232E+05	3. 970E-02
1. 05	1152. 30	0. 691	0. 163	0. 081	2. 094E-03	-1. 858E-14	-7. 610E-14	1. 835E+08	7. 140E-02
1. 30	915. 00	0. 690	0. 166	0. 083	2. 085E-03	-1. 805E-15	-7. 772E-14	5. 082E+13	3. 379E-02
1. 45	771. 39	0. 690	0. 167	0. 083	2. 084E-03	-1. 452E-16	-7. 781E-14	4. 229E+18	9. 911E-03

5 1. 533E+03 2. 500E-03 2. 500E-04 6. 120E+08 7. 270E+04 7. 250E-01 9. 700E-01 8. 257E-01 2. 000E+00

CASE NO. = 5

PARTICLE RADIUS(CM)= 2. 500E-04

PORE SURFACE(CM2/CM3)= 7. 270E+04

PORE LENGTH(CM/CM3)= 6. 120E+08

PRESSURE(ATM)= 1. 000E+00

MASS FRAX OF SOLID REACTANT= 9. 700E-01

NO. OF PARTICLE/MOLE OF GAS MIXTURE= 5. 341E+09

CA/S= 2. 000E+00

BULK DENSITY OF PARTICLE= 8. 257E-01

STRUCTURE PARAMETER= 4. 002E-01

SHERWOOD NO. = 2. 000E+00

VOLUME RATIO OF SOLID PHASE AFTER TO BEFORE REACTION= 2. 521E+00

TIME(S)	T(K)	POROSITY	CAPTURE	OACONV	XAB	RATEPA	SUMRPA	XKSEGM	DTIME
0. 00	1533. 00	0. 725	0. 000	0. 000	2. 500E-03	0. 000E-01	0. 000E-01	0. 000E-01	1. 430E-03
0. 30	1473. 15	0. 712	0. 061	0. 031	2. 348E-03	-8. 223E-14	-2. 854E-14	4. 931E+03	1. 160E-02
0. 55	1407. 39	0. 704	0. 099	0. 049	2. 253E-03	-6. 101E-14	-4. 619E-14	2. 884E+04	1. 783E-02
0. 80	1335. 58	0. 699	0. 126	0. 063	2. 185E-03	-4. 335E-14	-3. 899E-14	2. 419E+05	1. 795E-02
1. 05	1136. 60	0. 696	0. 140	0. 070	2. 150E-03	-1. 456E-14	-6. 559E-14	3. 576E+08	3. 461E-02
1. 30	915. 89	0. 695	0. 143	0. 072	2. 142E-03	-1. 591E-15	-6. 701E-14	4. 792E+13	3. 579E-02
1. 44	804. 40	0. 695	0. 144	0. 072	2. 142E-03	-2. 494E-16	-6. 708E-14	2. 188E+17	7. 250E-02
1. 45	769. 63	0. 695	0. 144	0. 072	2. 142E-03	-1. 214E-16	-6. 708E-14	4. 991E+18	5. 925E-03